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THE REVIVAL OF DE LESSEPS' SEA-LEVEL PLAN FOR THE PANAMA CANAL.

By Gen. H. L. Abbot, with an Editorial Introduction.

THE world has a right to demand from the United States, and the American public to require of any Commission charged with the construction of the Isthmian Canal, two things. First, the immediate and diligent prosecution of all work which will certainly contribute to the successful completion and operation of the waterway, whatever plan may be finally adopted; second, the most enlightened wisdom in the selection of the final plans, and the completion, in the shortest practicable time, of the canal most serviceable to the commerce of the world.

The former is chiefly a matter of engineering organization, and the efficiency already developed in the field work and other operations on the Isthmus was well reflected in the outline presented in these pages last month by Professor Burr, and is even more fully developed in the very valuable summary of the work now going on upon the Isthmus, and the proposed methods for prosecuting the construction of the canal, with which Mr. Grunsky, another member of the Commission, closes the leading pages of this number.

The latter and larger matter to be determined by the Commission is primarily the solution of a group of great problems in hydraulic engineering, to which the best studies of specialists intimately familiar with the data and conditions will lend invaluable aid. The Commission would ill administer their trust if they did not realize this and devote the needed time and thought to it. There is no need to urge that General Abbot's qualifications rank him very high among those whose counsel should be heeded, and we are glad to be the medium of his communications.—[THE EDITORS.

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THE advocates of the prompt construction of the best possible canal, now that we have secured what is well-known to be the best possible route, cannot but feel disappointed at the progress of events. We were first told by the daily press, some months ago, that it is necessary to begin examinations *de novo*, including surveys and all other details of the project, as nothing had been learned with sufficient accuracy to form the basis of a satisfactory American plan.

To say the least this was surprising. Much time and many millions of dollars had been devoted to the work of investigation by the New Canal Company, and in the opinion of competent engineers the data collected left little to be desired. Our Isthmian Canal Commission of 1899-01, after studies covering two and a half years, had expressed their opinion in the following language:

"The information relating to the topography, hydrography, and geology of the Isthmus is now much more complete than is usual before the inauguration of an engineering enterprise in a new country. The Canal Company spared no trouble or expense in laying it all before the Commission. The most important maps, drawings, and documents were lithographed or printed, and systematically arranged for the use of the Commission, copies being furnished for each member. Many other documents were supplied in manuscript. In all some 340 documents, many of them elaborate studies, were furnished. A list of them will be found in Appendix C. These supplied essentially all the data required for the preparation of plans and estimates though further information was desired as to the foundation upon which the great dam at Bohio must be built, and as to the area of the Chagres River drainage basin. This additional information was obtained by the field parties of this Commission. It was necessary also for the purpose of this investigation to verify the French data. Independent lines of levels, measurements of distances, borings, soundings, and hydrographic observations made by its own parties, supplemented by personal observation, enable this Commission to state that the data furnished by the Canal Company are essentially correct."

Confronted by this official statement, the early rumors were naturally attributed to the lack of knowledge of the authors. No well informed person can fail to recognize that the final plan requires time for the closest technical study, but it is equally true that a large force can be set at work at once without fear of future changes in plan causing loss. The excavations at the continental divide can be pressed with energy. In this connection it may be stated that experi-

ence has taught that the real problem at the Culebra lies not so much in the development of the extreme efficiency of the dredging machines as in securing the utmost rapidity of transporting the material to the dumps, which are a mile or two away. The necessary continual shifting of tracks, often under heavy rainfall, causes frequent derailments. If the steam engines—the heaviest vehicles of the trains—could be replaced by electric traction, the practical gain would be great. The construction of the dam at Alhajuela would enable this to be done. The surveys for the location of the branch railroad, 10 miles in length, and the plans for the masonry dam, which offers no serious problem, are completed, and were turned over to the Commission, and a large force could at once be put at work. If any element of the problem of the best possible canal is settled it is the necessity for this dam. It is needed for the regulation of the floods and freshets of the Chagres, and for the storage of the low-water supply when the canal is in operation; and it would be of immense service in controlling rises of the river during the construction of the Bohio dam, and in supplying electrically transported power for illumination and traction at the Culebra and elsewhere. The sooner it is completed the better for the progress of the canal construction.

But, of late, new rumors, this time from the Isthmus, are rife in the daily papers. The site for the dam at Bohio, although it has been approved by nearly every engineer who has studied the subject, is found to be unfit for the purpose. The site at Gamboa, although rejected again and again as unsafe, by competent engineers, is found to be favorable. Finally, the ancient sea-level plan of which M. de Lesseps was the father, and which brought ruin to his company, is again to be raised from the dead and seriously considered. So, at least, say the current reports. It is hardly necessary to add that they are without any actual foundation in the official reports or announcements of the Commission; but they are important in that they tend to mislead public opinion and throw the weight of popular demand on the wrong side of the case. It would be the irony of fate, if, after emerging from the clouds of obliquy under which his name has rested for so many years, M. de Lesseps should be recognized as the father of the American plan. Fortunately the new Commission has as yet given no sign of favoring the project, and as the responsibility of determining the plan rests upon it, and ultimately upon Congress, which alone can authorize so great an increase of the estimated cost and so great an extension of the estimated time, it is to be hoped that those who are counting on an early opening of the canal to the commercial needs of the country may not be disappointed.

The dream of M. de Lesseps was a canal without locks, but he was a diplomatist, not an engineer by profession; and indeed, the information then existing was wholly insufficient to justify any technical opinion on the matter. The Isthmian Canal Commission of 1899-01 definitely rejected the idea, stating: "The cost of such a canal, including a dam at Alhajuela and a tide lock at Miraflores, near the Pacific end, is estimated at not less than $240,000,000. Its construction would probably take at least twenty years. This Commission concurs with the various French Commissions which have preceded it since the failure of the old company, in rejecting the sea-level plan. While such a plan would be physically practicable, and might be adopted if no other solution were available, the difficulties of all kinds, and especially those of time and cost, would be so great that a canal with a summit level reached by locks is preferred."

It seems to be not without utility to elaborate more fully these other difficulties. The real object in view is the construction of the best possible canal when completed and opened to traffic. It may be remarked at the outset that a construction wholly without locks is impracticable at any expense, since the tidal oscillation of the Pacific, about 20 feet, can be controlled only by a lock near Miraflores. One lock being a necessity, the addition of four others becomes less objectionable. Furthermore, modern improvements in construction, since the time of M. de Lesseps, have worked a great change in opinion as to the difficulties they entail. On the Sault Sainte Marie Canal with its unequalled traffic, the Manchester Ship Canal, the Kiel Canal, and the Amsterdam Canal, they are in constant use, and are everywhere regarded as much less objectionable than are curves of short radius, because when the wind blows from the side or from the rear the latter offer far more serious impediments to navigation. It is true that locks cause slight delays; but when, as at Panama, the entire transit can be accomplished in a single day without encroaching upon the hours of darkness, this is a minor consideration. If locks are to be avoided only by introducing greater dangers and difficulties, it certainly is the part of wisdom to admit the locks. The true criterion is ease and safety of transit, and that this test leaves no doubt as to which type of canal should be preferred at Panama appears from the following review of the local conditions.

Near Gamboa, where the Chagres first joins the route of the canal, the bed of the river is about 45 feet above mean tide level, and since below that point the old bed (now occupied by the canal) followed the lowest depression in the valley, any new banks must dominate the latter for several miles. In other words, the water would natu-

rally pour into a sea-level canal in the form of a huge cascade. Hence there are only three possible solutions of a sea-level canal with one lock:—

(1) The plan adopted by the old Company was to excavate a new bed for the stream from Gamboa to the Atlantic coast. The opening of such a channel would demand not only enormous excavations, but also the construction of very high levees for several miles where the stream must dominate the canal. But such levees confining a river having so torrential a regimen could not but be a standing menace. It needs only to imagine a ship canal constructed parallel to and behind the levees of the Mississippi, to estimate the slight attractions such a canal would offer to mariners. Even with an upper lake to control more or less the floods of the Chagres, a canal having such a neighbor would be much less safe than a canal with locks judiciously planned, and hence would be distinctly inferior.

(2) Another solution would be to make the canal prism so large that, aided by an upper lake for partial regulation, it could carry the volume of the river. The advocates of this plan have not explained how they propose to deal with the natural cascade exceeding 45 feet in height at Gamboa, in order to admit the water to the canal. Thence to Alhajuela the natural bed of the Chagres rises four or five feet to the mile, and any grading would cause velocities too great to be seriously considered. But even admitting some solution of this problem of how to conduct the flow into the canal made large enough to carry the volume, the resultant current, always liable to considerable fluctuations, could not but interfere with easy and safe transit, as do curves. A canal with locks, judiciously planned, would be subject to no such drawback.

(3) A sensibly total diversion of the upper river, either to the Atlantic or to the Pacific, has been suggested as a third solution. Strictly speaking, this should provide for intercepting and diverting the run-off from the whole watershed of the Chagres above Bohio. But only about half of the flow at Bohio passes Alhajuela, and even at Gamboa, where the Chagres meets the line of the canal, it carries but 79 per cent. of the flow passing Bohio. This plan for diversion of the upper stream, therefore, would involve the abandonment of an excellent site for an upper dam at Alhajuela, and compel the construction of a dam at or near Gamboa, where the site is far from favorable. Furthermore, to convey away so large a volume—which might equal 65,000 cubic feet per second for a period of 48 hours—tunnels of large section must be driven for miles through materials which can only be made certainly known by trial drifts of equal

length; and this in a climate where the average daily temperature is 80° F. Moreover, the dam site at Gamboa, after careful examination, has been found to be so unfavorable as to be finally rejected by the engineers of the new company as unfit for a safe dam. It was favored by M. de Lesseps when the logic of events compelled him to abandon his sea-level project, but no detailed study and no works were ever attempted by him. But even granting that this third proposed solution is feasible from an engineering point of view, the canal would still be inferior to one with locks judiciously planned. The numerous tributaries of the Chagres between Gamboa and Bohio —that is, below the proposed diversion of the main stream—carry considerable volumes, fed by a rainfall greater than on any other part of the canal route. Entering laterally, these contributions would cause cross currents and eddies in the route for shipping never to be encountered in a really good canal. Furthermore, the Chagres, transformed from a useful friend into an enemy lying in wait behind the Gamboa dam, would threaten destruction in case of a failure like that of Johnstown, or serious delays in transit in case of any yielding in a long tunnel carrying rapid currents, where repairs would be excessively difficult. Is it safe to trust to a construction condemned by so many competent hydraulic engineers?

In fine, it is the unanimous opinion of all the engineers who have had practical experience in canal work, and time to study the problem thoroughly, that no sea-level project without locks, and no sea-level canal with a tidal lock, is practicable, that would be comparable in ease and safety of transit to one equipped with modern locks and planned to take advantage of all the desirable elements which the natural conditions offer. Why then waste an extra ten or a dozen years and untold millions of dollars, to execute a scheme which the investigations of thirty-five years have demonstrated to possess only a sentimental merit due to the imagination of M. de Lesseps? Congress and the American people are impatient for the opening of the best possible canal, and this involves well planned modern locks. The gates of those recently constructed at the sea entrance to the Amsterdam canal are operated electrically, and by a single man. At the Sault Ste. Marie canal, over thirty million freight tons have passed in a single year, although for some months it was closed by ice. The old prejudice against locks is rapidly passing away among hydraulic engineers conversant with modern progress. The Panama canal is an hydraulic problem, and should be planned in accordance with the dictates of modern science.

HYDRO-ELECTRIC POWER PLANTS IN THE CANADIAN NIAGARA DISTRICT.

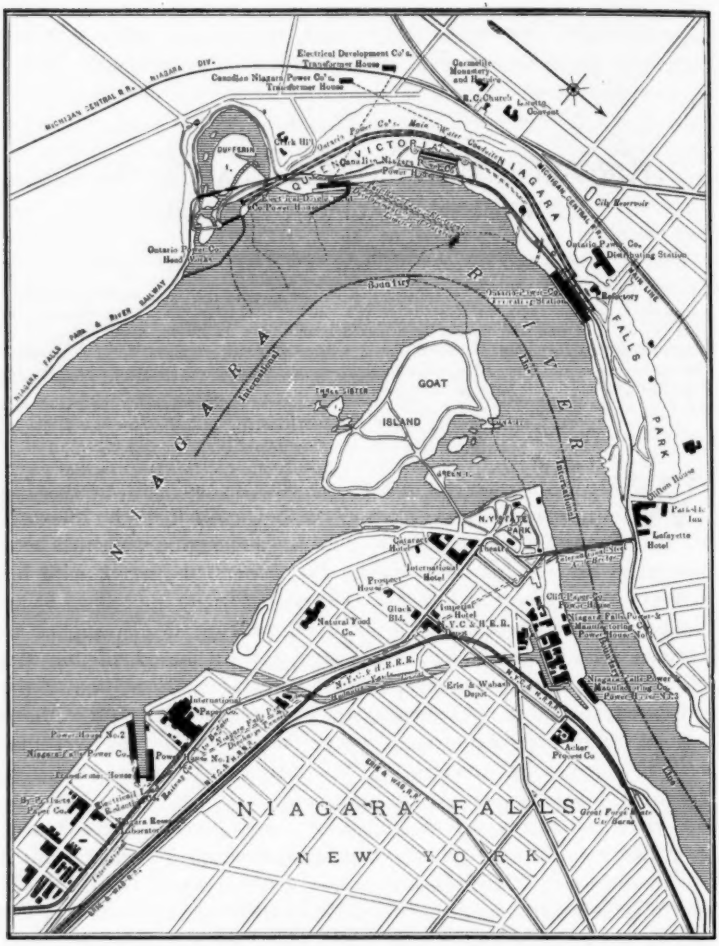
By Cecil B. Smith.

Mr. Smith was in charge of construction of the Canadian Niagara Power Company's plant from its commencement, some three and one-half years ago, until very recently, the first two units of this plant having been placed in operation on Jan. 1, 1905. He is therefore most intimately familiar with the entire scheme of development of the Niaraga water power, and this knowledge is reflected in the very clear and comprehensive survey of the Canadian projects which follows.—THE EDITORS.

"Force rules the world still,
Has ruled it—shall rule it."

WHAT this subtle thing is—so elusive and yet so powerful, so obedient and yet so deadly—I leave it to the knowing ones to tell you; but to the everyday engineer who has been for years busy at his task, sowing that others may reap, with his sense of achievement as his chief reward, electricity appeals as being a new and very pliable vehicle by which energy may be applied to various uses. Even among the many great achievements of the Nineteenth Century, the development of power ranks as one of the greatest from the point of view of an engineer; and although we have become so familiar with steam power that it scarcely receives that respect which it still deserves, this younger child commands homage, care, and admiring attention.

After the success of the Frankfurt experiments it became evident that long-distance transmission was the means by which a much wider scope could be given to this new force, and events have justified that belief to as full an extent in Canada as in any country in the world. The configuration of this country with its many rivers, flowing often down considerable declivities; a lack of coal near the greater centres of population; and the enterprise of its people—all have combined to make Canada rank second only to the United States in the development of hydro-electric power. It has now, according to Government statistics, 228,000 horse power of water power engaged in the production of electricity, representing over one-tenth of the world's total, and, by present indications, while a large amount of our water power is sure to be devoted to pulp

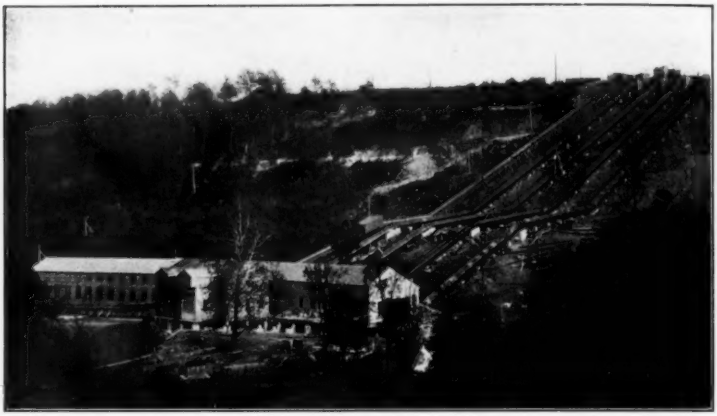

Electrical Development Co'y Transformer House
Canadian Niagara Power Co'y Transformer House
MICHIGAN CENTRAL R.R.
NIAGARA DIV.
Carmelite Monastery and Hermitage
R.C. Church
Loretto Convent
QUEEN VICTORIA
NIAGARA
QUEEN'S
DUFFERIN
Clerk Hill
Ontario Power Co. Head Gates
City Reservoir
Ontario Power Co. Operating Station
Ontario Power Co. Receiving Station
NIAGARA FALLS PARK & RIVER RAILWAY
NIAGARA RIVER
International
GOAT ISLAND
Terrapin Tower
Ontario Power Co. Tunnel
FALLS PARK
Refreshment House
Lafayette Hotel
N. Y. STATE PARK
Ontario House
International Hotel
Prospect House
Natural Food Co.
Clarke Bldg.
Imperial Hotel
N.Y.C. & H.R.R.R.
Niagara Falls Power & Manufacturing Co. Power House
Erie & Wabash Depot
Power House No. 2
Niagara Falls Power Co.
Power House No. 1
Power House No. 3
Niagara Falls Power Co. Transformer House
Niagara Falls Power Co. Power House
Niagara Falls Power Co. Receiving Station
Niagara Falls Power Co. Tunnel
Niagara Falls Power Co. Tail Race
Niagara Falls Power Co. Forebay
Niagara Falls Power Co. Intake
Niagara Falls Power Co. Gate House
Niagara Falls Power Co. Surge Basin
Niagara Falls Power Co. Tunnel Shaft
Niagara Falls Power Co. Tail Race Tunnel
Niagara Falls Power Co. Tail Race
Niagara Falls Power Co. Power House
Niagara Falls Power Co. Transformer

fluctuations in head, vigorous and varied markets, and reasonable freedom from ice troubles. Lake Erie is a big millpond which varies only slightly from day to day and season to season; so that if we even include the effect of the Chicago drainage canal's future increased draft, and Dr. J. W. Spencer's nerve-shaking statement that Chicago is lowering relatively to Niagara at the rate of 1½ feet per century, we may rest easy in the assurance that for two or three centuries at least there will be water to "burn."

While there are no large cities on the Canadian border at Niagara, the total population of southwestern Ontario within 125 miles of Niagara Falls is about 1,500,000 and, besides a great number of small manufacturing towns, includes Toronto (250,000), Hamilton (60,000), London (50,000), Brantford (20,000), St. Catharines (12,000), Stratford (12,000), Guelph (13,000), St. Thomas (12,000), Berlin (10,000), and others. Electric urban and interurban roads are steadily increasing. A great number of United States firms, such as the International Harvester Company and the Westinghouse Electric & Manufacturing Company, are building large Canadian works, and we may confidently look for 150,000 horse power being taken care of in one way and another as fast as it can be put on the market, in addition to which a large amount will be exported to help out the present plants on the United States side.

The difficulties with ice are largely matters of prophecy, as even those small plants already in operation are changing their conditions at the present time; but, roughly speaking, we may divide the plants into two classes—those drawing from large reservoirs, not subject to frazil or anchor ice, and those drawing from the rapids of the Niagara River and thus subject to frazil ice, anchor ice, and heavy drift ice in detached masses and in large floes. The special conditions of each plant will be touched on in connection with detailed information regarding these plants.

(A) Welland Canal Power Plants.—During the past fifteen years the *old* Welland has been practically closed to vessel traffic, and the Dominion Government has leased to various users limited quantities of water on each level, in addition to that already so used while the canal was in operation for vessel traffic, and in this way a large number of small stations have been equipped with ordinary stock turbines operating under 12-feet to 14-feet head, the power so produced being used for pulp grinding, flour mills, paper mills, calcium-carbide manufacture, electric light and power, and in other various important manufactures.



GENERATING STATION OF THE HAMILTON CATARACT POWER, LIGHT, & TRACTION CO., LTD., POWER GLEN, ONT.

The illustration shows the present development of the De Cew Falls plant. The original development consisted of the left-hand wing only of the building now shown, and a single penstock—the one farthest to the left in the picture.

In this manner some 10,000 horse power has been developed. As there are no rapids in which frazil or anchor ice can be formed, and as the slow current in the canal allows it to freeze over early in the winter, very little trouble is met with in operating through the winter season, except near St. Catharines where an hydraulic raceway of small dimensions and high water speed gets blocked by the excessive rise and fall in its water levels.

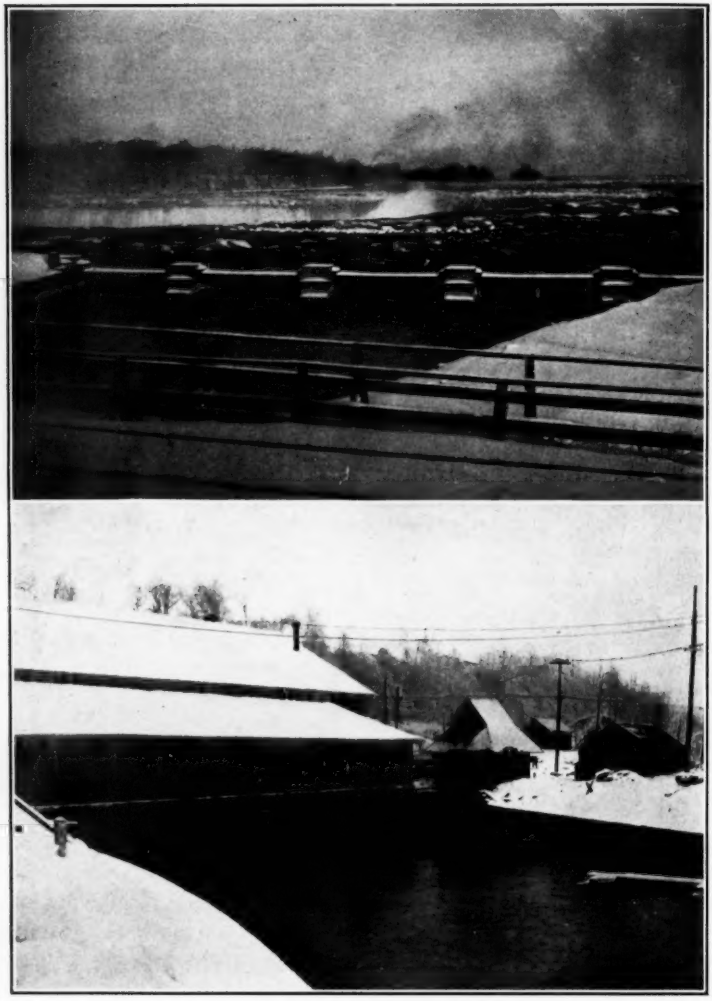
The De Cew Falls plant, about to be described, also draws its water from the Welland Canal.

(B) Hamilton Cataract Power, Light & Traction Company's Plant at De Cew Falls.—In 1895 the commercial operation of three 5,000-horse-power units at Niagara Falls Power Company's Power House No. 1 suggested to certain enterprising citizens of Hamilton, Ontario, the delivery of electric power into that city, and, negotiations with these and other parties having failed, a company was formed, water rights were obtained from the Dominion Government, and the construction of a plant drawing its water from the old Welland Canal at Allanburg was commenced. The installation was carried out by a headrace canal nearly five miles in length, a steel pipe down the escarpment with total head of 267 feet, supplying water to various horizontal units, and a natural tailrace leading to Lake Ontario.

Progressive equipment has been as follows: In 1897 a development of four 1,000-kilowatt units was prepared for and two of them were put in operation, the variation in water consumption being taken care of by large storage ponds at the brow of the escarpment. Later on the turbines, which had been installed by a well-known United States firm, were found defective and the plant was remodelled by installing two 2,100-kilowatt wheels made by A. Riva, Monneret & Co., Milan, Italy, operating at 286 revolutions, and by replacing the original two 1,000-kilowatt wheels by new wheels of Swiss design made by the same United States firm, thus giving a station of 6,000 kilowatts which has been in successful operation up to the present time and making current which has been taken to Hamilton (32 miles) at 22,000 volts (now changed to three-phase, 66 2/3 cycle, 40,000-volt transmission) and devoted to general use, including electric lighting, urban and interurban railways, cotton mills, knitting mills, flour mills, machine shops, foundries, rolling mills, etc., and as demands continued to exceed the supply, and many towns and villages in the vicinity had also to be taken care of, it was decided in 1903 to enter upon a second and more ambitious stage of development.

Additional water rights were obtained and a large canal excavated. The riparian rights in the Beaver Dam valley were taken over from the city of St. Catharines in exchange for a purer supply of water from Lake Erie, and reservoirs of 500-acres area and 10 to 40 feet in depth created. The added equipment when complete will consist of seven steel penstocks down the escarpment and a generating station of two 5,000-kilowatt and four 6,500-kilowatt units; and of these, four penstocks are now built, a generating station for four units built, and two 5,000-kilowatt units now in commercial operation. Each of the two present units consists of a horizontal spiral-case turbine operating under 267-feet head at 286 revolutions, made by J. M. Voith of Heidenheim, Germany, and discharging by two concrete draft tubes, direct connected to a 5,000-kilowatt horizontal alternator made by the Westinghouse Electric and Manufacturing Company and delivering three-phase, 66 2/3 cycle, 2,400-volt current.

We thus have a plant of a present capacity of 16,000 kilowatts, capable of being increased to 29,000 kilowatts by the addition of two machinery units and to 42,000 kilowatts (10 hour) by a moderate expenditure, and by reason of its large pondage area it is immune from ice troubles, can carry an overload quite easily, and even afford



CANADIAN POWER PLANT, INTERNATIONAL RAILWAY CO.

The upper view shows the entrance canal and the ice rack; the lower, the forebay and power house.

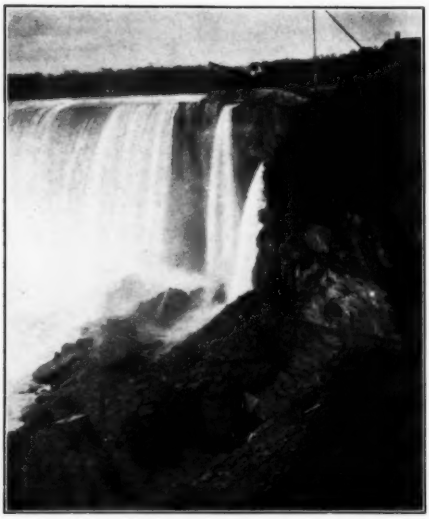
to have its supply cut off for short periods. It is a cheap installation without any pretense in respect to appearance, but with every effort to obtain first-class equipment; and operating under a good head,

within easy reach of a growing market, it may be looked on as a strictly business proposition and a money maker.

(C) International Railway Company's Plant at Niagara Falls, Ontario.—In 1892 The Niagara Falls Park and River Railway Company built a power house to operate their line from Queenston to Chippewa (11 miles) and, after excavating a small headrace and wheelpit and a tunnel, installed two 1,000-horse-power vertical turbine units, operating under 55 feet, made by William Kennedy and Sons, Owen Sound, Ontario. These were 45-inch new American downward-discharge wheels with wicket gate and single draft tubes. The shafts pass up through the centres of penstocks, and drive a countershaft to which were belted three 200-kilowatt 500-volt direct-current generators making current for railway purposes, and a few years later two 450-kilowatt 2,200-volt alternators for the temporary use of the Canadian Niagara Power Company.

This plant operated under considerable difficulties from ice, in spite of a large ice chute to wheelpit, because of its small headrace capacity and the high speed of approach, until 1903 when a remodeling of the plant was decided upon and at once commenced. The headrace was then made ample for 8,000 horse power, an ice rack added, forebay room extended, and old wheels repaired, also having their draft tubes lengthened and one of them being changed to a cylinder gate in order to control it by an automatic governor. The tailrace tunnel was enlarged and wheelpit extended sufficiently for placing one 2,000-horse-power, vertical, direct-connected unit which is now being installed by the Jenckes Machine Company, Sherbrooke, Quebec. This unit is a 60-inch inward and downward discharge single Francis turbine, and will operate under 60-feet head with a water balancing piston and high-pressure oil at thrust bearing and will be fully equipped with oiling and water-cooling systems.

The new generator is a General Electric 1,500-kilowatt direct-current 575-volt machine operating at 175 revolutions, and will work in conjunction with at least six 200-kilowatt belted machines and a bipolar booster (for Queenston service) from old wheels, giving a total immediate output of 2,700 kilowatts. The enlargement has been so carried out, however, that, by removing old wheels and enlarging wheelpit, three additional 1,500-kilowatt units can be installed in the present power house, using the present forebay and tunnel; this would give 6,000-kilowatts output, one-half of which would be for local use and one-half for transmission further east to carry loads in vicinity of LaSalle and Tonawanda, N. Y.



PORTAL OF TUNNEL, CANADIAN NIAGARA POWER COMPANY.
Taken in June, 1902.

At the river the ice rack has been supplemented by a boiler-plate curtain extending for two or three feet below water level. The head canal has ample capacity and is equipped with floating booms converging to an ice chute at the centre of the forebay, so that serious trouble need not be anticipated from either floating or suspended ice. In any vicinity but Niagara Falls, a water-power development of 6,000 kilowatts would bulk larger and receive more notice than this humble brother of the great dominating power plants of the Niagara district is ever likely to receive.

(D) Canadian Niagara Power Company's Plant.—In 1892 certain parties obtained from the Government and from the commissioners of Queen Victoria Niagara Falls Park a franchise for developing power from the waters of the Niagara River above the Horseshoe Falls, and after futile efforts to float the scheme in England and Canada, where confidence in such a development had not yet been established, turned it over, at a nominal sum, to the Niagara Falls Power Company; but it was not until the spring of 1901 that actual development began. At this time the Ontario Power Company was becoming active and the Niagara Falls Power Company's Power House No. 2 nearing completion.

In outlining the design for this plant, certain evident advances on previous similar installations were decided on which consisted mainly of (1) 10,000-electrical-horse-power generators of internal revolving-field type; (2) consequent shortening of wheelpit, power house, etc. from 80 feet per 10,000-horse-power to 48 feet per 10,000-horse-power; (3) generating voltage three-phase, 25-cycle, 12,000-volts, which enables local long-distance transmission to be made without transforming; (4) revolving parts of unit fully supported by

high-pressure oil thrust bearing as a reserve to water-balancing piston support.

The first installation contemplated a completed tailrace tunnel for 110,000 horse power, and this is now finished. It is 25 feet high and 19 feet wide, of an inverted horseshoe section, and is lined with 15 inches of concrete faced with 4 inches of highly burnt shale brick, the arch, however, being entirely of brick. The tunnel has a grade of 7 feet per 1,000, is 2,200 feet long, and empties, one-half submerged, by an ogee curved portal 100 feet long, lined with 2 feet of granite and finishing in a square headwall carried 34 feet below water level. The rock being largely shale, a full timbered arch and plumb posts were required, and excavating was carried on by a full top heading and two benches, arch timbers and wall plates being kept close up to the heading and plumb posts inserted at the time benches were being driven.

In order to construct the canal and forebay, a somewhat extensive cofferdam was placed in the swift and deep water of the Niagara River and, after fulfilling its mission, is now being removed. The design was one of two lines of cribs with an 8-foot puddle space and held together by iron turnbuckles. The puddle—a mixture of gravel and clay—was very effective; but owing to the boulder formation of

WHEELPIT LINING WALLS AND ARCH CENTERS, CANADIAN NIAGARA POWER COMPANY.

the river bed under the cribs, it was considered advisable to carry a water-tight double tongued and grooved sheeting down to rock on the inside and toe it with concrete, which reduced the pumping to nominal proportions and remained absolutely intact for over two years.

The entrance canal and forebay are also built complete for 110,000 horse power and, being spanned by a wide stone arch bridge of graceful design, and contained by rock-faced ashlar walls surmounted by parapets with fine bush faced copings, present a pleasing and yet massive appearance. This basin, under normal conditions, will have 15 feet of water, and with plant in full operation will require a speed of approach of only one foot per second across the forebay, thus encouraging the formation of a surface ice sheet and consequent rising of anchor and frazil ice to the surface. As a first line of defense, an outer ice rack is provided which will take care of those occasional runs of heavy ice which occur after a protracted period of east winds; and a line of submerged arches supporting the forebay room of the power house will tend also to check the progress of that fine slush ice which will pass through the outer rack.

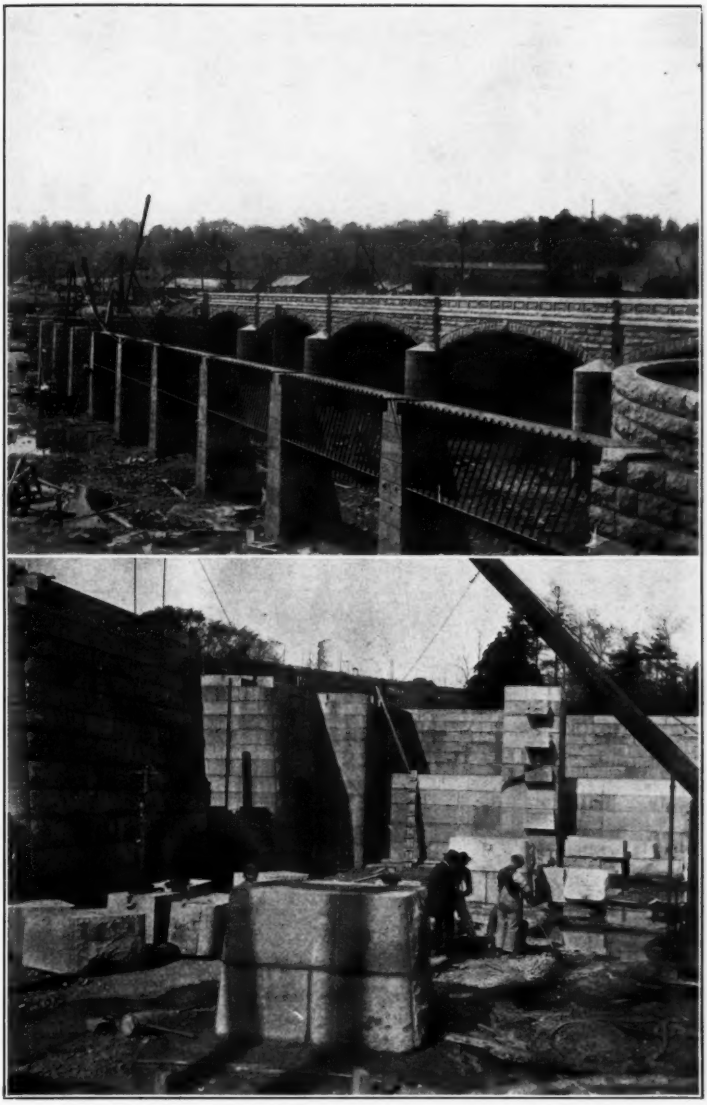
At the down-stream end of the forebay, submerged weirs have been added with a sluiceway returning to the river, and taking advantage of the fall in the river a drop of some two feet is creatable at this point, thus inducing floating materials either inside or outside the forebay room to pass back into the Niagara River.

The entrances to the penstocks are through 18-foot openings in the main breast wall, and cast-iron mouthpieces set in the main pit walls, each entrance being controlled by steel head gates raised and lowered by means of screws and 20-horse-power motors.

Along the face of the breast wall and inside the forebay room a continuous line of fine ice racks is placed, with the centre section removable, so that should ordinary raking not prove effective in caring for weeds, chips, and ice, the latter may be gotten rid of by the "*dernier ressort*" of raising up the racks by means of a forebay crane and letting the wheels take care of it.

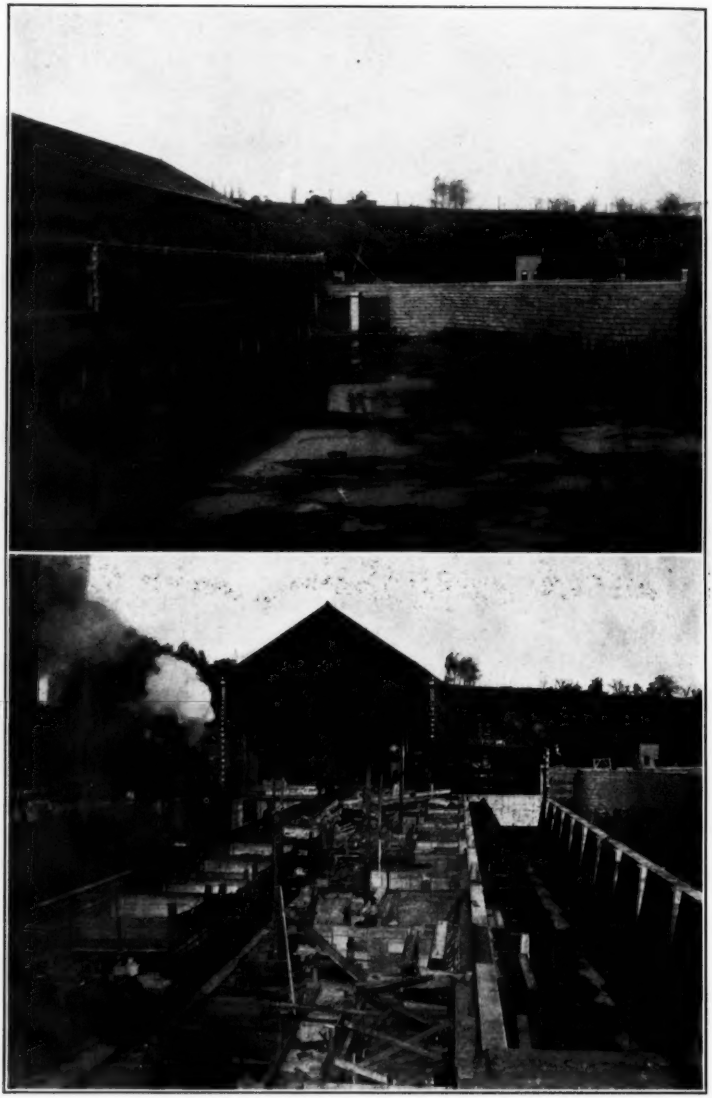
The wheelpit for receiving the hydraulic machinery is equivalent to a sky-scraper building, depressed so that its roof is at the ground level. It is 570-feet long, 18-feet wide, and varies from 165 feet to 148 feet in depth, the bottom being on a grade of three feet per hundred toward the tunnel which flows from its lowest point toward the lower Niagara level.

The wheelpit is lined with 15 inches of brick anchored to the



PORTIONS OF THE HEADWORKS, CANADIAN NIAGARA POWER COMPANY.

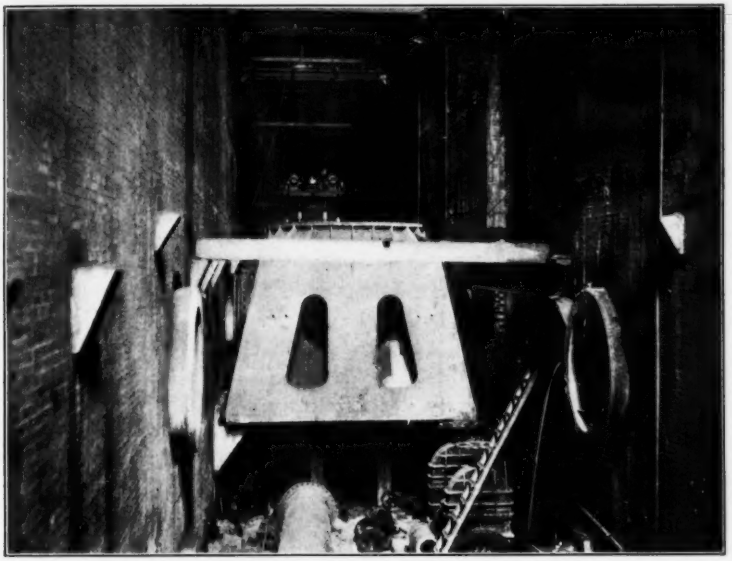
The upper view shows the outer ice rack and stone arch bridge as it appeared in July, 1904; the lower, taken in the October preceding, shows the inlet, weir, and forebay pier masonry.



POWER HOUSE CONSTRUCTION, CANADIAN NIAGARA POWER COMPANY.

The upper view is taken along the inlets, inner ice rack and forebay; the lower one is a general view of the forebay and power house. Both represent the condition of the work in October last.

solid rock behind, the first course next to the rock being hollow to take care of water leaking in from river; and it is divided into various floors or decks necessary for operation of machinery. There is also a passenger elevator, and two 50-ton cranes traverse the power house surmounting the pit, making possible the installation of the enormous castings, machinery parts, etc., which fill it, while the actual construction of the pit itself, after being channelled, drilled, and blasted, was carried on by two travelling 10-ton hoists working along the edges of the pit.



TURBINE INSTALLATION, UNITS 1, 2, AND 3, CANADIAN NIAGARA POWER COMPANY.

When the Niagara Falls Power Company equipped their first power house they used twin free-discharge wheels, each of 2,500-horse-power capacity, or 5,000 horse power per unit. The next step in advance was made at their second power house, where the wheels are single inward-discharge wheels with draft tubes, of 5,500-horse-power capacity; all of which naturally led to the Canadian Company installing twin inward-discharge vertical Francis wheels of a capacity sufficient to turn out 10,000 electrical horse power under 136-feet effective head, operating at 250 revolutions. These were designed by Escher, Wyss & Company, of Zürich, who are also contractors for three units now commencing operation, and I. P. Mor-

ris Company of Philadelphia are installing two units, making 50,000 horse power for the present installation. The current is produced by direct-connected 10,000-electrical-horse-power, three-phase, 25-cycle, 12,000-volt machines with internal revolving fields, made by the General Electric Company, and is controlled by an elevated switchboard located on the main power-house floor and parallel to its length, with corresponding bus-bar compartments in a subway immediately underneath.

Naturally, a power plant of this extent has a large amount of auxiliary machinery, but nothing of this nature mars the sweep of vision in the power house itself; lined with enamel brick, marble, and buff brick, it presents from the visitors' gallery a simple and dignified panorama in keeping with the magnitude of the work. In secluded chambers, however, burrowed into mother Earth from the side of the pit and just above the lowest floor, are found the pulse, nerves, and lungs of the large machines. In one are vertical direct-connected turbo-generators making 1,000 horse power of 125-volt direct current for excitation and for operating cranes; in another, two 3,000,000-gallon horizontal centrifugal pumps, also turbine-driven, are prepared to supply water one-half mile distant to cool the transformers; and in still another are many tanks, filters, and pumps for high and low-pressure oil service, whose mission it is to force through the brass oil-pipe systems the oil necessary for proper operation, and to cool and clarify it on its return. Finally, there is installed at the tunnel exit a huge lift gate sliding in grooves and handled by screws and an 85-horse-power motor. This gives absolute control of the level of the water in the lower reaches of the wheel-pit, no matter how many large units are in operation.

The power-house building is of Queenston limestone and having a tile roof is practically fireproof. It will be considered, by even critical observers, fit for its purpose, substantial and dignified, while the forebay room facing the river, with a tiled promenade roof, affords a viewpoint worthy of Niagara Falls.

For the disposal of power generated, the Park Commissioners require underground conduits to points beyond the Park, and these have been built entirely of concrete and tile, spaced generously to afford heat-radiating capacity, and large enough to carry 50,000 horse power to Niagara Falls, N. Y., and 50,000 horse power to a transformer station south of the Park. This station is for the present equipped for 25,000 horse power, with oil water-cooled transformers, and has separate high-tension and low-tension rooms, the

long-distance connections being for 40,000 or 60,000 volts. It is a fireproof building with concrete floors and tile roof.

Adjacent to the transformer is a standpipe 116-feet high and 30-feet diameter, holding one day's reserve supply in case the pumping system at the wheelpit or the rising main to transformers should get out of order, and, as it is located on high ground, it dominates the landscape. Speaking generally, the company can, with a relatively small additional expenditure, complete its machinery and transformer equipment to 100,000 horse power with an eleventh wheel in reserve, and as the plant has been designed and built substantially and along well tried lines, it forms a powerful auxiliary to the two 50,000-horse-power plants of the Niagara Falls Power Company already in operation. The three stations working in parallel on opposite sides of the river, and of a total of 200,000 horse power, can with confidence defy chance and the elements and offer to consumers almost absolutely certain and continuous power.

UNDERGROUND CONDUITS THROUGH THE PARK, CANADIAN NIAGARA POWER CO., MAY, 1904.

(E) The Ontario Power Company's Plant.—In 1887, before the wheelpit and tunnel-tailrace method of development had become so fully established as it now is at Niagara Falls, a charter was obtained from the Dominion Government for a power plant using a headrace canal which was to obtain its water from the Niagara River via the Chippewa River by reversing the natural direction of flow of the latter stream. This scheme included a group of tunnels for chuting the water from this canal to another canal at a somewhat lower level situated in Queen Victoria Park, from whence it was to be carried over the cliff at Table Rock to a generating station situated on the lower river level. This canal scheme was abandoned, however, in

CONCRETE GATHERING DAM AND OUTER FOREBAY, ONTARIO POWER COMPANY.

1902, and the present one adopted, which is to create a large receiving basin in the Niagara River Rapids immediately in front of the beautiful Dufferin Islands, at a point 1¼ miles from the site of the power house, and to convey the required water through a flume along the park surface to Table Rock, from which penstocks branch off downward through tunnels to the turbines situated in the generating station founded on the talus at the foot of the main cliff and about 200 yards north of the Horseshoe Falls.

Naturally, the public, jealous of the beauty of the park being marred, observed this arrangement with consternation; but its interests have been well safeguarded and the ultimate restoration of the Dufferin Islands is assured, when water is brought to its future level in the receiving basin adjacent. So also through the Park itself the flume, which is an 18-foot steel pipe encased in concrete, is to be covered over and the park surface terraced so as to disguise its presence.

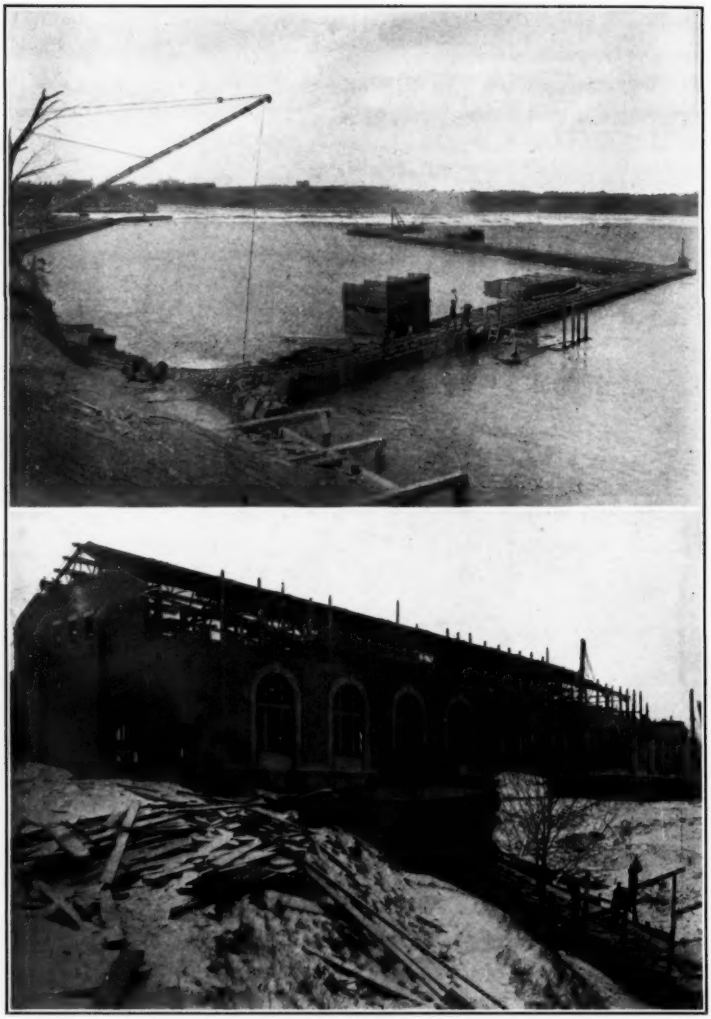
The present construction, which is being vigorously pushed, and which is well on toward completion, comprehends a receiving basin for 180,000 horse power, with ample water to spare for restoring the Dufferin Island channel and for washing over the spillway dam and weirs at normal river level. As this basin is located at the head of the upper Niagara Rapids it is not likely that frazil or anchor ice will have to be

dealt with. This basin, after being unwatered by cofferdams, was partly excavated in solid rock and partly formed by the concrete spillway dam, and is divided into outer and inner portions. The outer one is protected at the river face by a curtain wall of submerged concrete arches placed obliquely to the current which will tend to pass along floating ice and debris. There are three outlets from this basin, openings for admitting water around the Dufferin Islands, the main screenhouse, and the overflow dam already referred to. The screenhouse has vertical openings and steel grillages, set on inclined guides in concrete, and these grillages are removable by means of a crane, while from a visitor's point of view,

EIGHTEEN-FOOT PIPE, BEFORE BACK FILLING. ONTARIO POWER COMPANY.

the promenade on the roof of the screenhouse has a very fine outlook on the adjacent rapids. The water, after passing through the inner basin, approaches the gate house which consists of three 18-feet openings controlled by Stoney gates and surmounted by a substantial building which it is proposed to equip with boilers and steam pipes.

At present one 18-foot flume is built through the park to the power house and it is proposed to carry water through it at over 15 feet per second to operate six pairs of horizontal Francis turbines and to develop 60,000 electrical horse power, which proposal will raise in the minds of hydraulic engineers the question of the regulation of this enormous mass of swift moving water. The methods which the



CONSTRUCTION WORK ON THE PLANT OF THE ONTARIO POWER COMPANY.

The upper view shows the diverting dams to unwater the intake site; the lower one shows the distributing and transformer station as it appeared in the middle of December last.

company's engineers employ to this end and the results attained will be of great interest. From the bottom of the flume six steel penstocks are carried by shafts and tunnels to the generating station, one to feed each pair of turbines. Each penstock has a gate valve and expansion joint and bifurcates to the two machines. The generating units are direct-connected and each consists of two horizontal Francis turbines, operating at 187½ revolutions, made by J. M. Voith of Heidenheim, and a 10,000-electrical-horse-power, three-phase, 25-cycle, 12,000-volt, internal revolving-field generator, made by the Westinghouse Electric & Manufacturing Company, and each unit occupies a floor space of 26 by 50 feet. Concrete draft tubes in pairs will take the tailrace water from the machines to a weir over which the water will discharge into the river. The only equipment of importance, in addition to the main units, located in the power house, consists of 1,000 horse power of exciter units (to be used not only for excitation but for lamps, motors, switches, etc.) and the turbine governors, and these are elevated at the rear of the station close to the cliff so as not to obstruct the floor space of the large units.

The power house is a substantial concrete structure, with a heavy flat steel-trussed roof, modestly crouching close to the overhanging cliff, and visions of roof gardens made verdant by the constant spray will dull the edge of any criticism anent the proximity of this pigmy work of man to the stupendous spectacle which is an emblem of the power of the Almighty.

Contrary to usual custom, the control of this station has been placed in a building on the upper plateau and over 500 feet distant; here will be located not only the controlling switchboard gallery, connected to the generating station by control circuits laid in underground conduits, but also to this same point will be brought the generated current through insulated underground cables. The building has three transformer compartments, as in the Canadian Niagara Power Company's transformer station—one for low-tension switches, a second for the water-cooled transformers themselves, and a third for the high-tension switches—and as it has a very prominent location overlooking the whole Niagara panorama, some attention has been given to the harmonious appearance of that side facing the falls.

While the head works are of 180,000-horse-power capacity, the remaining construction is being carried on with a view to the generation of 60,000 horse power, which suggests that, should an enlarged market be discovered or created in the near future, the public visiting the park will be subjected to turmoil and disorder for many years

to come, long after the other two companies have put their respective areas into that condition which will satisfy the park authorities and adorn the landscape. Under present conditions, however, the park should be largely restored during 1905, and current from these works, as now under construction, placed on the market.

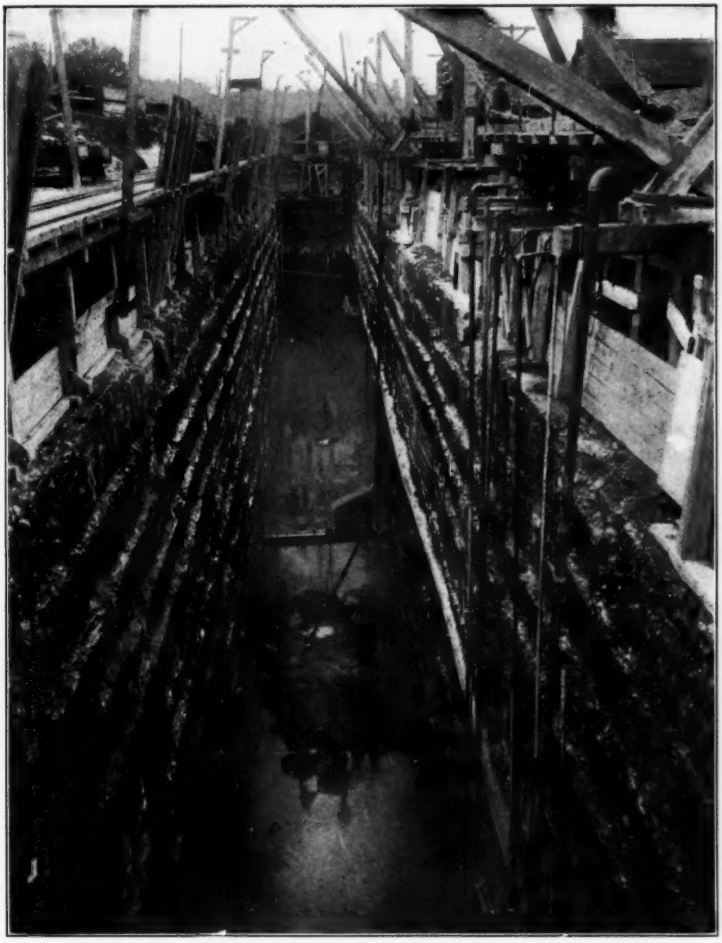
(F) Toronto and Niagara Power Company's Plant.—Not content to purchase power from other parties, certain Toronto capitalists obtained rights from the Government and park authorities in 1903 and, under the name of the Electrical Development Company of Ontario, at once commenced the construction of a third large power plant at Niagara Falls; and, appreciating the merits of the wheelpit method of development, formulated plans which, while maintaining the general idea of the Canadian Niagara Power Company's works, contain strong features of divergence which are briefly:

(1) Shortening the length of pit to 75 feet per 20,000-horsepower output, as compared with 96 feet for the Canadian Niagara Power Company, this being done by reversing the penstock positions of each alternate machine, thus using a common hatchway for each two units.

(2) Placing the turbine cases and lower penstock elbows on the bottom of the wheelpit instead of suspending them across the wheelpit above the tailrace. This method involves the extension of the tailrace tunnel by means of two branch tunnels, one on each side of the wheelpit and somewhat below it, and carrying a draft tube from each machine into one of these tunnels, in connection with which it is proposed to place a controlling gate at the outlet of each branch tunnel, enabling one-half of the plant to be shut down for examination or repairs in the tunnel without interfering with the operation of the remaining machines.

(3) Concrete arches across the pit at various elevations for each unit which will take the place of the steel guide and thrust girders used for carrying vertical revolving shafts of previous wheelpit installations. These concrete arches will also act as struts to prevent that creeping of walls which has been so interesting a feature of previous wheelpits.

(4) Excavation of tailrace tunnel under the bed of the river to a point behind the sheet of water of the Horseshoe Falls. This has necessitated the omission of any permanent portal work, owing to the recession of the falls, and the tunnel, although to be lined with continuous concrete faced with brick over the greater portion of its length, is to have a concrete lining made of short annular rings for



WHEELPIT EXCAVATION, TORONTO & NIAGARA POWER COMPANY, AUGUST, 1904.

300 feet from its mouth, providing for a gradual falling away of the tunnel lining, year by year, for a century at least.

This tunnel, some 1,900 feet long or 3,160 feet long including branches, is about one-half completed, the excavation being carried on by a construction shaft and horizontal tunnel extending from the west shore of the river to a point near the mouth of the main tunnel; and, after breaking through to the face of the gorge behind the falls,

which was accomplished under perilous circumstances, the excavated rock has been thrown out and swept away by the falling sheet of water. This tunnel is to have a very large section, 26 feet high, 23½ feet wide, and the grade of 5½ feet per 1,000 is estimated to be capable of passing 12,000 cubic feet per second when running full.

Unlike that of the Canadian Niagara Power Company, the forebay or receiving basin for this plant is being created in the Niagara River midway between the entrance works of the two companies whose works have just been described; and, as the site selected was at the most boisterous part of the rapids, it became necessary to throw out a cofferdam enclosing this basin, extensive in length and cost and perilous in its execution beyond that of those cofferdams already built for the other companies. It is interesting to note that French Canadians have shown themselves to be peculiarly adapted for this class of work, where familiarity with handling of timbers, etc., in the raging rapids has to be combined with cool daring and endurance under continual exposure to the elements.

This cofferdam is composed of two lines of cribs with a puddle space between, but on completion the leakage under it was found to be so great that a third line of cribbing and second puddle space, a

TIMBER ROOF OF TUNNEL, TORONTO & NIAGARA POWER CO.; VIEW TAKEN SEPTEMBER, 1904.

COFFER-DAM BUILDING AT A CASCADE, TORONTO & NIAGARA POWER CO.

gathering flume for the leakage from the upper portion, and secondary or cross lines of cribbing with wide puddle slopes, have been resorted to, and the basin has been unwatered in detail and a very heavy spillway dam constructed which, while mainly of concrete, is capped with granite, and will take care of any overflow of water and ice which the fluctuations of the water level may subject it to. The downstream end of this gastering or spillway dam is to be three feet lower than the main portion, thus affording an outlet for heavy ice even under lowest water conditions; and some distance outside the power house is a line of submerged concrete arches coped with limestone above water, which will be the first line of defense against floating ice or debris, and the large receiving basin created will give slow velocity and tend to favorable treatment of frazil ice which may form in the rapids above. The power house proper is to be a very ornate structure of Italian Renaissance style, and will face landward. It is to contain, ultimately, eleven 8,000-kilowatt, three-phase, 25-cycle, 12,000-volt generators revolving at 250 revolutions which will be direct-connected to twin turbines situated in the wheelpit immediately beneath. The rear wall of the power house will consist of another series of submerged arches through which the water will pass to an

PART OF THE HEADWORKS, TORONTO AND NIAGARA POWER CO.

The upper view, taken in November, 1903, shows the cofferdam in place, but not yet puddled; The lower one, taken one year later, shows the upstream end of the spillway dam.

inner bay within the power house itself. This bay will have a spillway at the north end emptying into the river below, and the water before entering the penstocks will pass through an ice rack to screen floating debris out of it.

In the wheelpit will be situated eleven turbines for driving the generators just mentioned, and the hollow shafts connecting each turbine to its generator will be supported by concrete arches at two points besides at the thrust bearing. The single draft tubes from each turbine will empty upward by a sinuous course into the *bottom* of the tunnel alongside, and will therefore always be sealed. This pit is now completely excavated and good progress has been made on the draft-tube and branch-tunnel excavation. The pit excavation was carried on by drilling holes about six inches apart along the sides, which gave a fairly good surface when the benches were blasted, and was cheaper and quicker than the channelling done on previous wheelpits; but it is probable that some trouble will be experienced in fastening the brick lining to this shattered and uneven surface, especially as the leakage from the river through the seams of the rock is very heavy. This plant will have also the necessary auxiliary equipment of exciters and oil pumps, located in chambers branching off from the wheelpit, but has not yet reached the machinery stage of construction.

The company have also commenced the construction of a transformer station situated on the bluff above the park, and proposes to transmit current to Toronto, 80 miles, by three-phase, 60,000-volt transmission, the wires to be carried on steel towers 400 feet apart; it should be prepared to deliver in the summer of 1905 if current is obtained temporarily from other companies, but otherwise it is not likely that commercial service can be given to Toronto before late in 1906.

In considering the Canadian Niagara Power situation broadly, certain striking features are at once presented. We find financial faith in a demand for power at last established, although this has been rather slow in coming, but now that $20,000,000 to $30,000,000 is being invested the markets must be found.

Hamilton and district can take care of the output of the De Cew Falls plant, and the Hamilton Company are not likely to meet much opposition as they are well entrenched. Toronto, in the same way, will be subject to the Toronto & Niagara Power Company's sway, as its allied companies control the street-railway and electric-light franchises and exert a powerful influence in the city. The Canadian

Niagara Power Company is an allied company of the Niagara Falls Power Company and will be apt to export a large amount of power to the United States whenever additional markets are found there.

The fields yet unexploited are many. Steam railways will probably turn to electric when they feel *absolutely sure* of continuous power, and the group of Niagara plants should now make this possible. The various power companies also hold large blocks of land at Niagara Falls, Ontario, and will doubtless induce smelting and manufacturing industries to locate in the vicinity, and, beyond all, the many manufacturing towns in the centre of western Ontario are still unsupplied.

How much all these various demands will amount to it is difficult to estimate, but as there will be 150,000 to 175,000 horse power on the market from these plants in a few years, and as they are being developed with a view to a total output of 375,000 to 400,000 horse power, it is a safe conclusion that the probable demand within the next five years will about equal the smaller amount mentioned. On the other hand it is hard to conceive of a total demand in both countries within a present reasonable distance of Niagara Falls of more than 500,000 horse power within the next generation.

Those who are in a good position to know, however, are perhaps the most uncertain as to the future possibilities in electrical transmission and developments in the use of this and other forms of heat and power, and while we may, with apparent wisdom, build expensive works designed to endure for centuries, and say "Look how massive and grand," who can tell but that some new form of energy, or some new way of directing and using it, may, as so often has happened in the past, make these investments seem mistaken and shortsighted? For:

> "They have given to mortal man the immortal scope,
> The perilous chance, unrest, remembrance and hope,
> That imperfection may come to perfection still
> By some fabled shore."

THE ECONOMY OF SMALL-SIZE COAL FOR THE POWER PLANT.

By Percival Robert Moses.

The utilization of the small sizes of coal, formerly rejected—and, indeed, the recovery and marketing of these sizes from the old culm banks where they had long since been thrown—has passed into quiet acceptance as a phase of the modern tendency to find use and value in what was once mere waste. It is interesting chiefly in that it influences very directly the all-important question of the conservation of the world's fuel supplies. Mr. Moses presents a practical study of the matter as it affects the cost of operating the power plant, and the equipment and management of the fire-room.—THE EDITORS.

THE following brief discussion of the use of small anthracites —Nos. 2 and 3 buckwheat and other low-grade fuels— is undertaken with the idea of spreading more widely the knowledge of the value of low-grade fuels, and their great importance in the problem of reducing the manufacturing cost of power.

In the average power plant, the cost of fuel is at least two-fifths the cost of manufacturing power, and in some instances it equals three-fifths of this cost. The remainder is two-thirds labor, and the balance, oils, sundry supplies, repairs, water, etc. The two main items are fuel and labor, and this paper will be confined to one branch of fuel economy—i. e., the economy obtained by reducing the original cost of the fuel, and not that obtained through increased efficiency of engines, pumps, or other steam users.

The foundation of economical plant operation is low steam cost, and the less efficient—that is, the more wasteful—the rest of the plant is in the use of steam, the more important is the cheapening of the cost of making this steam. This fact, although axiomatic, is very generally overlooked, and while large amounts of money and "gray matter" are devoted to the gaining of a small percentage in the steam economy of engines or pumps, the burning of coal under the boiler and the complete utilization of the heat derived from this coal are matters left to the discretion of the boiler maker or the operating engineer; and even the largest plants, such as that of the New York Edison Co., have been handicapped from the start by imperfect design of grate surface.

For the same reason that efficient and cheap production of steam is more important than its efficient use, the question how to obtain the greatest amount of heat from a dollar's worth of coal is more important than the question how best to use the heat obtained from this amount of coal, although both are important. To make these points more clear, it will be well to consider briefly a modern isolated plant having from 300 to 500 horse power of engines, 30 to 40 horse power of pumps, and 300 to 500 boiler horse power. In such a plant, the coal fired under the boilers would transfer about 70 per cent. of its heat to the water in turning it into steam, and the remaining 30 per cent. would be lost, mainly up the chimney but partly through the walls of the setting and through the doors and exposed surfaces of the boiler. It is apparent than any increase in the efficiency of utilizing the heat from the coal, such as would be obtained by baffling devices in the path of the gases, by economizers, or by increased tube surface, would tend to reduce only this 30 per cent. loss, and the maximum benefit that could be hoped for would not exceed 15 per cent., as the temperature of the gases going into the chimney must be at least 100° F. higher than the temperature of the steam, even with artificial draft; and air from 50 to 100 per cent. in excess of that required theoretically for complete combustion must be supplied and must be heated to the temperature of the chimney gases. Even this apparent possible saving of 15 per cent. would usually be offset by the cost of the appliances necessary to accomplish the result. On the other hand, if by any means the number of units of heat obtainable from a dollar's worth of coal could be increased, the cost of the 70 per cent. valuable heat would be decreased in direct proportion, and the cost of the 30 per cent. waste heat would be decreased as well; that is, the saving would apply to the whole quantity used.

Before taking up the question as to how the quantity of heat units obtained from a dollar's worth of coal may be increased over the usual practice, it will be well to carry out further this consideration of losses in the plant to emphasize the greater importance of saving at the beginning of the operation of power manufacture than at the end of the process.

Assuming that 70 per cent. of the value of the fuel has been used in changing the water in the boilers into steam at 80 to 125-pounds pressure, the next point to consider is what percentage of this steam energy may be used in the engines and pumps and other power-producing apparatus. A simple high-speed engine requires 35 to 45 pounds steam per horse-power hour under usual load conditions, a

compound high-speed engine from 22 to 26 pounds; simple pumps from 150 to 250 pounds, and compound pumps, 75 to 100 pounds per horse-power hour. As an engine or pump or other mechanical horse power is equal to 2,545 heat units per hour, and the production of a pound of steam under usual working conditions of feed water and pressure requires approximately 1,000 heat units, the foregoing figures of steam per horse-power hour show that with the compound engine about 10 per cent. of the steam energy is used, with the simple engine about 6½ per cent., and with the simple pump about 1½ per cent.; or, reducing these percentages to the basis of the original heat in the coal, allowing for the 30 per cent. loss, the compound engine actually utilizes about 7 per cent., the simple engine 4½ per cent., and the simple pump 1 per cent.; or putting it another way, from 93 per cent. to 99 per cent. of the energy in the coal is wasted. This is the case where the steam can be used for power only; where it can be used in the heating system or for other low-temperature work after doing its power work, more or less of the 63 per cent. to 69 per cent. remaining of the 70 per cent. available energy can be saved, as has been pointed out many times.*

Considering these figures, it will be seen that doubling the efficiency of a simple pump would decrease the loss only from 99 per cent. to 98 per cent., while doubling the efficiency of the dollar's worth of coal, would make the loss only 50 per cent. of what it was before. Furthermore, the increased efficiency of engines or pumps would be a real saving only during periods in which the steam required by low-temperature uses for heating, etc., was less than the exhaust supplied by the engines, while the saving from increased efficiency of the dollar's worth of coal would be a direct benefit at all times.

I do not wish to be misunderstood as advising lack of care or study in increasing the efficiencies of the various pieces of apparatus using energy. The figures showing the wastage are sufficient evidence of the need of care in this line, and these same figures indicate the direction in which this economy can be obtained—viz., consolidation of the various functions as far as possible, and reduction of the number of inefficient steam-using pieces of apparatus; or, as a practical example, substituting electric-driven pumps for simple steam pumps, electric elevators for steam elevators, electric-driven small compressors for small steam compressors, and supplying all these

* Economy in Design and Operation of Electric Plants, THE ENGINEERING MAGAZINE, January, 1903. Efficient Use of Steam and Labor in Isolated Plants, ibid. October, 1898.

from a high-efficiency engine and electric dynamos, which should also supply the electricity for lighting, cooking, etc. The length to which this consolidation can be carried is limited by the size and character of the apparatus and the comparative cost of the electric and steam drive, but for small pumps and compressors the electric drive will be found to cost barely one-half as much as the direct steam.

But to return to the main line of the paper, the point emphasized is the high relative importance of the cost of the heat in the coal, and the value of any cheapening of this cost.

It is impossible, in anything less than a book, to touch on all the grades and kinds of fuels, and such a discussion would be of little value, as the costs of fuels will vary in different localities, and the fuel that is cheapest in a sawmill might be dearest in the vicinity of a coal mine.

In New York City and other cities of the eastern American seaboard, unless the conditions are special, the use of anthracite (hard) coal for isolated plants is general. This coal is screened to different sizes, known to the trade as Furnace, Egg, Chestnut, Pea, No. 1 Buckwheat, Rice or No. 2 Buckwheat, Barley or No. 3 Buckwheat. Owing to the presence of slate and other impurities the average heat value of small coals is not usually as high as that of the larger coals, and this difference is more marked in the very small sizes, but it is quite possible to obtain a No. 3 Buckwheat coal with more heat units per pound than No. 1 Buckwheat.

Large-size Egg or Chestnut may have 14,500 units of heat—that is, a capacity (with perfect combustion) of raising 14,500 pounds of water one degree. Bituminous coal yields from 13,000 to 14,000 units of heat per pound of coal, and the smaller sizes of hard coal known as Pea and No. 1 Buckwheat, from 11,000 to 12,000 units of heat and—here is the main point—the still smaller sizes of hard coal known as No. 2 Buckwheat or Rice, and No. 3 Buckwheat or Barley, will average over 10,000 units of heat per pound. With a furnace and boiler capable of utilizing 70 per cent. of the heat units in the coal and test conditions, egg coal would evaporate from 9½ to 10 pounds of water per pound of coal, into steam at 100-pounds pressure; bituminous coal, about 9 pounds; No. 1 Buckwheat, 7½ pounds; and No. 3 Buckwheat, 7 pounds. In other words, the average No. 3 Buckwheat or Barley coal is only 10 per cent. less valuable, as far as its capacity for making steam is concerned, than the No. 1 Buckwheat or Pea Coals, and is only about 20 per cent.

less valuable than the soft coals or the larger anthracites. This is not a new story; it has been told by the large anthracite-mine operators for the past four or five years; but while the theory was correct and the facts were as stated, a great many difficulties developed in the burning of the small-size anthracite, and these, together with the low price of No. 1 Buckwheat, prevented their general introduction up to the period of the great coal strike. This strike finally resulted in a rise of 70 cents a ton in No. 1 Buckwheat, and of 80 cents a ton in Pea coal, and the immediate result was the investigation of methods of burning the smaller sizes known as Rice and Barley. The price of Rice delivered in New York City is approximately the price of No. 1 Buckwheat before the strike—i. e., $2.55 per ton. The price of No. 3 Buckwheat is about 30 cents less, so that if No. 3 can be used in place of No. 1 Buckwheat, the saving at present prices would be nearly $1 for each ton of coal burned. The saving in actual practice is about 60 cents a ton, the difference being due to the power required to produce forced draft and the slightly lower average heat value of the No. 3 than the No. 1 Buckwheat.

The prices of Pea, Buckwheat, and the smaller sizes of steam coals have been about as follows during the past two years. These prices are in lots of 25 tons delivered in buildings in New York City:

Pea Coal	From	$3.65	to	$3.85	per	ton	of	2,000	pounds.
No. 1 Buckwheat	"	$3.10	"	$3.35	"	"	"	"	"
No. 2 "	"	$2.50	"	$2.65	"	"	"	"	"
No. 3 "	"	$2.25	"	$2.35	"	"	"	"	"

In order to compare these coals on an equal basis, and to find their true value to the user, it is simpler to state the number of heat units in a dollar's worth of coal, and these would be as follows:

Pea Coal	6,400,000	heat	units	per	dollar.
No. 1 Buckwheat	7,200,000	"	"	"	"
No. 2 "	8,400,000	"	"	"	"
No. 3 "	9,120,000	"	"	"	"

This comparison is still not quite correct, as deduction should be made for the steam required to supply forced draft needed in order to burn the No. 2 and No. 3 Buckwheat coals, except with exceptionally high smoke stacks and large grate surface. The steam required for this purpose varies from 2 per cent. to 3 per cent. with fan blowers, to 8 per cent. with steam blowers, and the final comparison would therefore be, with No. 3 Buckwheat as standard of value.

	Large Plants using Fan Blowers for Small Coal.	Value.	Small Plants using Steam Blowers for Small Coal.	Value.
Pea Coal.....	6,400,000	72.7	6,400,000	76.
No. 1 Buckwheat....	7,200,000	81.8	7,200,000	85.7
No. 2 "	8,150,000	92.6	7,800,000	93.
No. 3 "	8,800,000	100.	8,400,000	100.

Of course, where No. 2 or No. 3 can be burned without forced draft, the former comparison will hold; and, as a matter of fact, the steam used for forced draft is by no means a complete loss, as it results in more perfect combustion and less surplus of air, so that in practice the loss of steam is largely made up by increased efficiency. To place the matter in concrete form, if the expenditure in a plant is at the rate of $30 per day at present for No. 1 Buckwheat, it could be reduced to between $24 and $25 by the use of No. 3 Buckwheat under forced draft.

There are two methods of burning this small coal, both of which require a forced draft. It has been found by experience that, in order to burn the small-size anthracites, it is necessary to have a draft of one-ounce pressure per square inch in order to secure a proper mixture of the air and coal. The best method, for small plants of 500 horse power or less, requires a steam blower to produce the necessary pressure in the ashpit. There is a great variety of these steam blowers on the market. The main requisite is to have an adjustable rate of steam emission from the nozzles so that when the steam pressure falls the opening can be made larger, and the same quantity of air discharged into the ashpit.

The steam blower produces a pressure in the ashpit by the expansion of steam emitted from small orifices with a difference of 40 pounds or more between inlet and outlet of orifice. The rush of steam with this difference in pressure produces a powerful suction through the space surrounding the openings, causing air to be drawn into the ashpit and discharged under pressure through the grate openings.

The second method employed for plants of over 500 horse power requires a centrifugal fan similar to that made by the Sturtevant Co., or Buffalo Forge Co., with galvanized-iron air ducts carrying the air to the ashpit. The fan system is more economical in its use of steam but takes up a great deal of space, and the ducts are bulky and difficult to install in a plant already in operation.

Of importance next to, if not greater than, that of the apparatus for producing the draft and delivering the air, is the system of grates

The number of grates devised for burning the small-size coal is very large. Here again two distinct principles are met; the first, largely used with steam blowers, consists of a heavy, almost solid grate with small openings spaced 3 or 4 inches apart. With grates of this character, the ashes do not fall into the ashpit at all, but are drawn out through the fire doors, the good fire being pushed back onto a so-called cleaning platform.

The other system of grates is built on a principle exactly contrary to this, and as much air space as possible is left. Grates have even been devised made of wire mesh. This type of grates is used almost exclusively where the pressure is obtained from the use of a centrifugal fan or blower, or when the natural draft is sufficient.

In both systems of forced draft, the draft-producing apparatus is controlled automatically by a valve opening or closing the steam supply as the steam pressure of the boiler falls or rises. In some cases an ordinary damper regulator is used, controlling a balance valve in the line from the boilers to the steam blowers.

Where the fan blower is used, a reducing valve is installed which opens, more or less widely, the steam connection to the engine driving the blower, allowing the blower to speed up or slow down, but not to stop completely or run away.

With either system, when the blast is at its maximum, the tendency will be to drive the gases through the boiler and up the chimney without giving up the full amount of heat. This would be particularly the case if the damper opened wide at the same time when the blast pressure was at its maximum. In order to minimize this waste, the damper is frequently controlled so that at a point of maximum blast the gases going up the chimney will be sufficiently held back to prevent undue waste of heat, and at the same time not so much as to cause the gas to be blown out into the fireroom.

Under forced draft with a fan blower, the tendency to clinker is noticeable, and this can be greatly reduced by blowing the exhaust from the steam engine in with the blast. With the steam blower no difficulty is experienced with clinker, particularly with the type of grates mentioned. Where it is feasible, it is advisable to have the blast into the ashpits pass through the back connection of the boilers, thus allowing the air on its way to the furnace to be partially heated. In a few cases a system of pipes in the smoke flue has been installed, through which the air was delivered to the blast apparatus; such devices must be of very low efficiency and of small value.

There are no bad effects to boilers or setting with a forced-draft

system, provided it is properly handled and intelligently installed. The grates must be larger in order to burn small anthracites than to burn the larger sizes, and they must be designed for the work. The combustion chamber, too, should be designed for ready cleaning, as the pressure of the blast tends to carry over fine ashes and soot instead of allowing it to remain on the grates, and there are a few similar minor points to be taken care of in the setting and connection of the boilers.

Firing is somewhat harder with No. 3 Buckwheat than with No. 1 Buckwheat, as firing and cleaning must be done about twice as often; but the quantity of ashes taken out each time is less, and generally no increase in the force is necessary. Where there is only one boiler, and this is run one shift and banked the remainder of the day, some difficulty is experienced over night and in starting up next morning. Unless the draft is exceptionally poor, it is always possible to raise sufficient steam pressure to run the blowers.

The forced-draft system is of no advantage with an insufficient chimney area, as it is impossible to push a column of heated air through too small an area of stack, for instead of going up the stack it will find its way back into the fire-room.

With a correctly designed and proportioned setting, and ordinary intelligence in handling, there is no reason why the smallest sizes of anthracite fuel and other low-grade fuels should not be substituted for No. 1 Buckwheat and Pea coal and a material saving obtained.

ELECTRIC-POWER SUPPLY FROM CENTRAL STATIONS IN GREAT BRITAIN.

By G. L. Addenbrooke.

The importance of Mr. Addenbrooke's subject, from the merely material point of view, is indicated by his conservative estimate that the immediate prospective investment in electric power supply in Great Britain is £100,000,000, and that with the approaching electrification of the railways this amount may be trebled. The movement, like the development of Niagara, described by Mr. C. B. Smith elsewhere in this issue, is further marked by its certainty scarcely less than by its magnitude. We are especially glad to present, in this issue of THE ENGINEERING MAGAZINE, reviews so clear and comprehensive covering the most significant power undertakings—technically, financially, commercially, or economically considered—which the age affords.—THE EDITORS.

IT has been put to me that a short review of the present position and prospects of this industry would be interesting. The subject is, however, of so far-reaching character, and such changes and progress are being made at the present time, that this is by no means an easy task.

The first attempts to put into commercial shape the calculations and proposals of engineers in the direction of public electric-power supply over extended areas were made in the Parliamentary session of 1897-8, when the group of provisional orders applied for by the Midland Electric Corporation and the bill of the General Power Distributing Company, which latter was of a much more ambitious character, came before a joint committee of the two Houses of Parliament presided over by Lord Cross. The general views which were formed by this committee, as a result of the evidence laid before it and as given in a report which it subsequently laid before Parliament, have formed the basis on which committees appointed to deal with electric power bills have since acted.

Supported by the recommendations of this committee, the Board of Trade granted the powers asked for by the Midland Electric Corporation; but the bill of the General Power Distributing Company was rejected by the special committee before which it subsequently came, owing to the opposition of the large towns included in the area. The fight, however, was a most useful one, as it showed the lines on which a bill would have to be framed to secure fair chances of passing in the face of the antagonistic frame of mind with which it was evident the larger authorities would meet proposals of this character.

In the next year's session, the increasing opposition shown by the local authorities to extensions asked for by the Midland Electric Corporation made it clear that the method of applying for powers, by means of groups of provisional orders, which was favoured by the Board of Trade itself, had little or no chance of being successful again if tried elsewhere on a large scale; and the session was barren, except for the first bill of the Walker and Wallsend Company, on which a large and flourishing business has since been founded, though this bill covered an area of only about 4 square miles.

In the meantime, the matter was being reconsidered by a certain number of men connected with the electrical industry, and as the general advance of electric-power distribution in other countries showed more clearly its practicability, notices for two groups of bills were given in the session of 1899-1900, and in the ordinary course came before what is familiarly known as "Sir James Kitson's committee." These groups of bills comprise, on the one hand, the South Wales Electrical Power Distribution Company's act and, on the other, the Newcastle-on-Tyne Electric Supply Company's act, and the County of Durham, the Lancashire, and the North Metropolitan acts. I have divided these acts into two groups, because there is an important fundamental difference in their character. In the South Wales act, power was obtained to deal direct with consumers. In the other acts, supply could be given only in bulk and through local authorities, or other authorised undertakers, who had to obtain separate powers to carry out the distribution themselves. Of these two groups of acts, it is obvious that the South Wales type is the better act from the commercial and engineering points of view.

The passing of these acts set up a double standard—supply through authorities in cases where the opposition of the local authorities was extreme, and direct supply to customers in cases where arrangements could be made with these authorities. Subsequent legislation has proceeded on these lines, though every year since there has been a greater tendency on the part of promoters to draw their bills on the lines of the South Wales act, and Parliamentary committees, seeing the useless difficulties and complications entailed in supplying through the local authorities, have been more and more willing to grant powers on what may be briefly called "South Wales" lines.

Encouraged by the success of these acts, promoters succeeded in 1901 in obtaining powers for the following electric-power acts—the Cleveland & Durham, the Clyde Valley, the Yorkshire, the Derby-

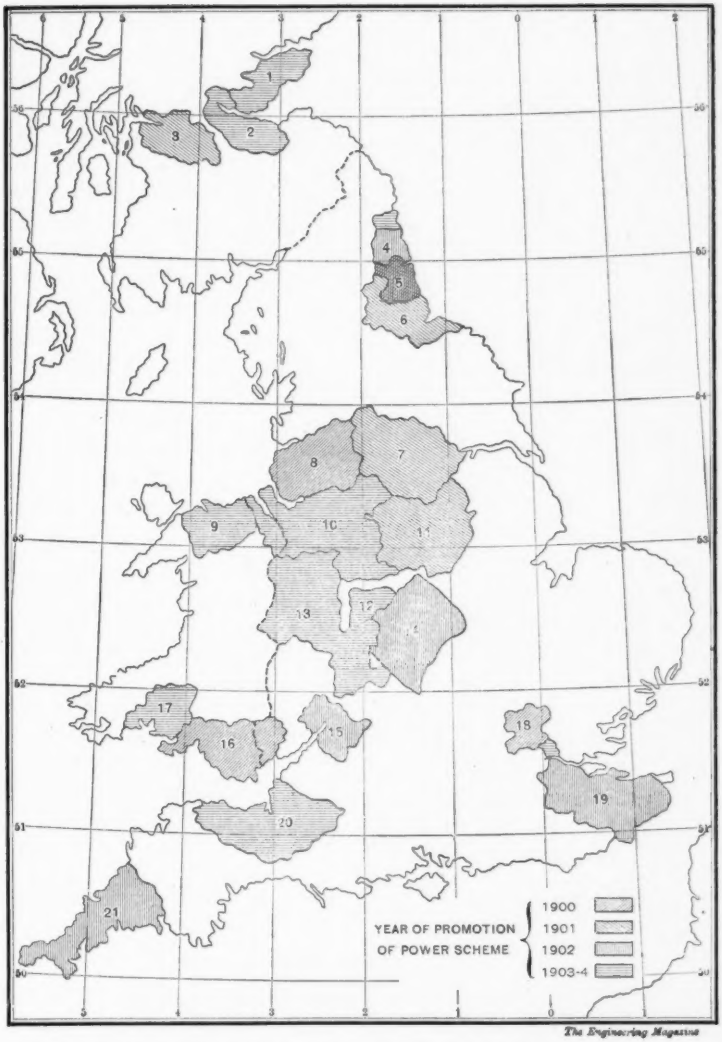
shire & Nottinghamshire, and the Shannon Water Power acts. These were followed in the session of 1902 by the Leicestershire & Warwickshire, the Carmarthenshire, Cornwall, Gloucestershire, Kent, and certain supplementary power acts. In 1903, the Fife Electric Power act, the Shropshire & Worcestershire, the North Western, comprising parts of Staffordshire and Cheshire, the Scottish Central, the Somerset & District acts, and the act amalgamating the Walker & Wallsend Company with the Newcastle-on-Tyne Electric Supply Company were passed. In 1904 an act covering a large part of North Wales, and in which the generation is intended to be by water power, was the only act passed. This, therefore, represents the position of matters today from a legal aspect. The areas covered by these acts are shown approximately in the accompanying map, and may be said to cover nearly all the important industrial areas in the United Kingdom which are not comprised within the boundaries of large towns. The map will be found on page 765.

From this short review it will be seen that the history of electric-power legislation already extends over seven years, during which time the principles involved, both practical and general, have been subjected to the criticism of technical and commercial men. At their first inception, these projects were looked upon doubtfully by a large proportion of the engineering profession; but, owing to the technical advances which have taken place since the idea was first promulgated, scepticism in the profession itself on the score of practicability has become a negligible quantity. Indeed, the ground for criticism is now confined to the question whether power companies will be commercially successful in the face of the prices at which those who require mechanical power can generate it for themselves.

While, however, advances have been made during the last seven years from what may be called the "private-supply" point of view, still greater advances have taken place on the central power-supply side of the question, and particularly during the last eighteen months facts and data have come to light which, when thoroughly digested, must in the opinion of any fair-minded man who thoroughly examines the question, tell in favour of central power supply in a large proportion of the cases where mechanical power is required. It can now more and more clearly be shown, not only from engineering calculations but from appeals to accomplished facts, that a power company moderately financed, with well-designed works and good administration, in any area in which there is a sufficient demand for its product, should form a sound commercial investment for capital.

This leads us directly to the consideration of what is the present position of the power companies and what are their future prospects. It is one thing to obtain an act of Parliament granting powers for the accomplishment of some definite object, however desirable, and another thing to obtain the necessary capital and to carry these powers into effect; and this is especially the case where the undertaking breaks fresh ground and precedents cannot readily be appealed to. The acts above enumerated were most of them obtained during years of prosperity. Now experience shows that after an act of Parliament is obtained, it nearly always takes at least eighteen months or two years before plans can be fully prepared and the necessary financial arrangements made for putting the work in hand; and thus it has happened that before the majority of these power companies were ready with their projects in final form, they were face-to-face with what are called in financial parlance "lean times," when the difficulties of raising money for large undertakings are greatly enhanced. Under such circumstances, acts of Parliament are not infrequently allowed to lapse altogether; and the very fact that work under them is proceeded with is a great test of the strength and vitality of the movement which underlies them. It is, therefore, doubly interesting to enquire into what has actually been accomplished in obtaining capital and commencing works by the companies constituted under the acts enumerated above.

In the first place, it must be premised that the promoters of power companies have never been able to hold out to investors the possible prospects of obtaining that huge return on investment which is the attractive feature of mining and similar speculative classes of enterprise. The objects that the promoters of power companies have had in view have been to create sound industrial undertakings, offering a moderate but safe return on capital invested, such as is obtained in the case of railways and water or gas stocks. Although when the dividend-paying stage is once passed capital can be readily found to almost unlimited amounts, yet for these very reasons the initial stages are more difficult, particularly when the enterprises are of a technical character and do not very readily appeal to the information and intelligence of the general public. For these reasons, a very large proportion of the finance which has so far been found for the power companies has been obtained through private channels, or has come from people more or less directly connected with the movement and who have had special opportunities of forming a judgment of the prospects of the undertakings in which they are investing. It is



The Engineering Magazine

SKETCH MAP SHOWING THE AREAS IN ENGLAND, SCOTLAND, AND WALES OVER WHICH PARLIAMENTARY POWERS FOR ELECTRICITY-SUPPLY HAVE BEEN OBTAINED.

The companies holding the powers designated by corresponding numbers on the map are as follows:—1, Fife; 2, Scottish Central; 3, Clyde Valley; 4, Newcastle Electric Supply—Newcastle and District Lighting; 5, County of Durham; 6, Cleveland and Durham; 7, Yorkshire: 8, Lancashire; 9, North Wales; 10, North Western; 11, Derbyshire & Nottinghamshire; 12, Midland; 13, Shropshire & Worcestershire; 14, Leicestershire & Warwickshire; 15, Gloucester; 16, South Wales; 17, Carmarthenshire; 18, North Metropolitan; 19, Kent; 20, Somerset; 21, Cornwall. Powers have also been granted to an Irish company known as the Shannon.

obvious that capital obtained in this way is far more difficult to come by than in cases where an issue can be readily underwritten and a successful appeal made to the public at large. From the fact that most of the capital at present embarked in the power companies has been obtained in this way, it is not easy to give cut-and-dried figures in each instance, but data and information in my possession show that, so far, a sum of about £4,000,000 has already been spent or is in process of being spent on these enterprises in the United Kingdom, and this sum will probably increase by another £1,000,000 in the current year. This sum is a small one when compared with the capital which may ultimately be needed when the movement is thoroughly established—indeed, I think it probable that within the next fifteen years a capital of £100,000,000 will hardly cover the work which lies before the power companies; and should, later on, the railway companies work with the power companies in taking the supply they may require for electrification purposes, this capital may even be doubled or trebled. Nevertheless £4,000,000, the approximate sum so far subscribed, is a large amount in itself, and is also a large sum to be already embarked in undertakings of this character which were first practically brought forward only seven years ago, and which on their inception have had to contend with very great difficulties, both legal and financial.

As has been stated, it usually takes between two and three years after an act has been obtained to conduct the final negociations with local authorities and other parties interested, to rearrange the personnel of the company with a view to active operations, to get out a final and satisfactory engineering scheme, and lastly to secure the necessary financial support and backing, the latter operation naturally being dependent a good deal on the state of the financial world at the time. For these reasons a number of the companies above enumerated have hardly had the requisite time since their acts were passed to complete their arrangements for making a practical commencement of their works, but several of the companies constituted under the earlier acts have already done so, and it is proposed now to give a brief account of some of these.

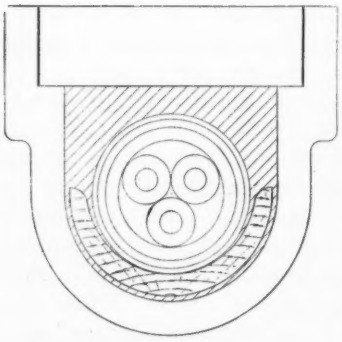
The amount of space which can be devoted to each company in this article, which is intended to be of the nature of a general review of the situation of the power companies, is small. It must be remembered that each is already either a large undertaking or is the nucleus of one, and, further, that each one presents special and distinctive engineering features with regard to the conditions of supply

and the character of the customers to be served. All that can now be done is to give a few brief particulars of the operations of the leading companies to date.

The company which has thus far attracted the largest amount of attention from writers is the Newcastle & District Company, formerly called the Walker & Wallsend Company. At an early stage this undertaking entered into a close alliance with a company owning the lighting supply of a large part of Newcastle-on-Tyne. The company was also able to secure the supply of a system of electric tramways, and as its power station is located in the midst of a number of shipbuilding and engineering works of a character very suitable for electric driving, it was at an early stage able to secure a large clientele and has been from the first a sound dividend-paying concern. Later it secured a bulk supply for the County of Durham Power Company, operating on the south bank of the Tyne, and recently obtained a contract to supply the North Eastern Railway with the power needed for the electrification of about 37 miles of main-line railway. To meet these and other increases in the demand for power for works within its area, the company has lately completed a new station on the Tyne, at Carville. As a matter of general interest, a photograph is reproduced (p. 769) showing two of the 7,000-horse-power Parsons turbo-generator sets already installed, and attention may also be drawn to the portion of the building itself which is shewn in the background and which, it will be noticed, consists of an iron framing with corrugated galvanized-iron sides. This company has recently enlarged its district to the north and is commencing the supply of a large colliery area in Northumberland.

Another company which started contemporaneously with the above undertaking is the Midland Electric Corporation for Power Distribution, Limited, whose district covers a large portion of what is known as the "Black Country." This company, though founded primarily as a power company, has been rather treated by its present administration as a lighting company giving a certain amount of power supply, and thus its progress has been by no means so rapid as it might have been (considering the richness of its area) had a bolder policy been pursued. It is, however, accumulating a large business and is supplying light and power in at least two directions up to distances of eight or nine miles from its power house.

The company, however, which is at present attracting most attention is the South Wales Electrical Power Distribution Company, whose rights are practically co-extensive with the celebrated South

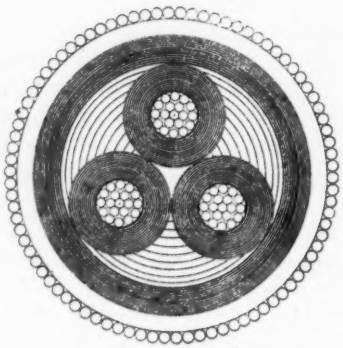


CABLE AND 4-INCH EARTHENWARE TROUGH, SOUTH WALES.

Callender's Cable & Construction Co., Ltd., London.

Wales coalfield. This company is being watched closely because it has been administered from the first purely as a power company and has been started entirely off the ground, so to speak—that is, without reliance on existing lighting or tramway supply or on contracts negociated beforehand. The moving spirit has been Mr. Graham Harris, the surviving partner of the firm of Sir F. Bramwell & Harris, engineers, of Westminster, assisted by a powerful backing of electrical manufacturers and local men of influence. The undertaking had to meet many difficulties at the start, and questions of policy have made it desirable to start three smaller stations to serve various portions of the area, as well as the main generating station which lies below Pontypridd at the foot of the Rhondda Valleys. Two illustrations of this station are given, one showing an exterior view, the second (on page 770) a portion of the generating plant.

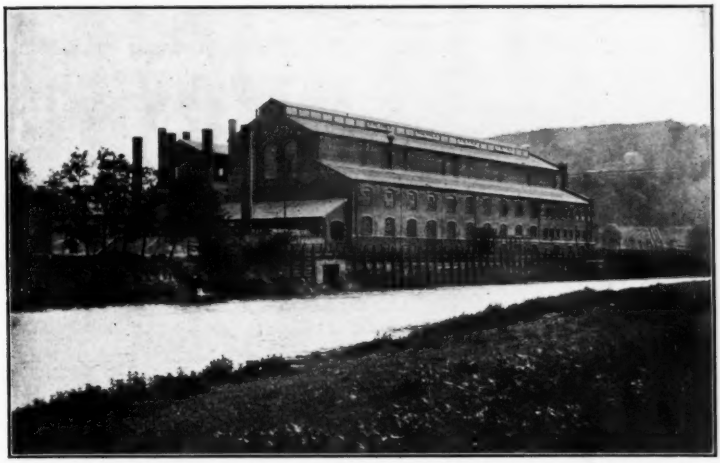
The points of interest are that the water-tube boilers are each furnished with a separate iron chimney, instead of one large stack for the whole. The generator plant shown consists of two Willans-Ganz sets, each capable of indicating about 3,000 horse power. Three further similar sets are also ordered and are to be immediately installed to meet the growing load. The station is situated on the banks of the Taff, whence the water for condensation is derived.



SECTION OF CABLE, 11,000 VOLTS, SOUTH WALES.

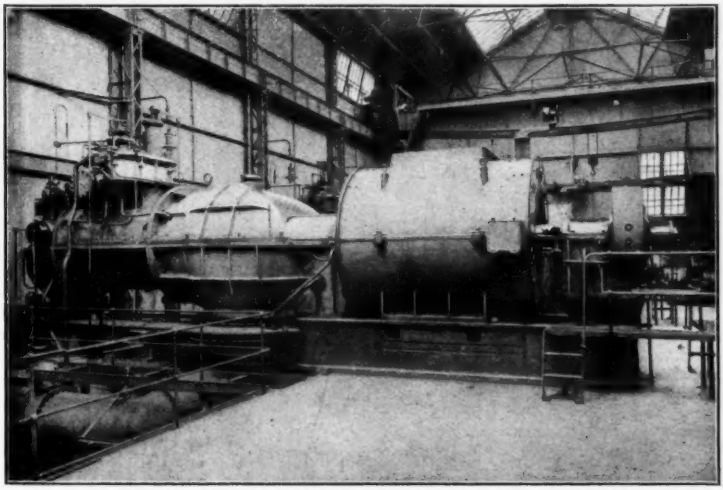
Paper-insulated and lead-covered, Callender's Cable & Construction Co., Ltd., London.

This station has now been in operation about nine months, feeding a large system of mains with three-phase currents at 25



PONTYPRIDD POWER STATION, SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.

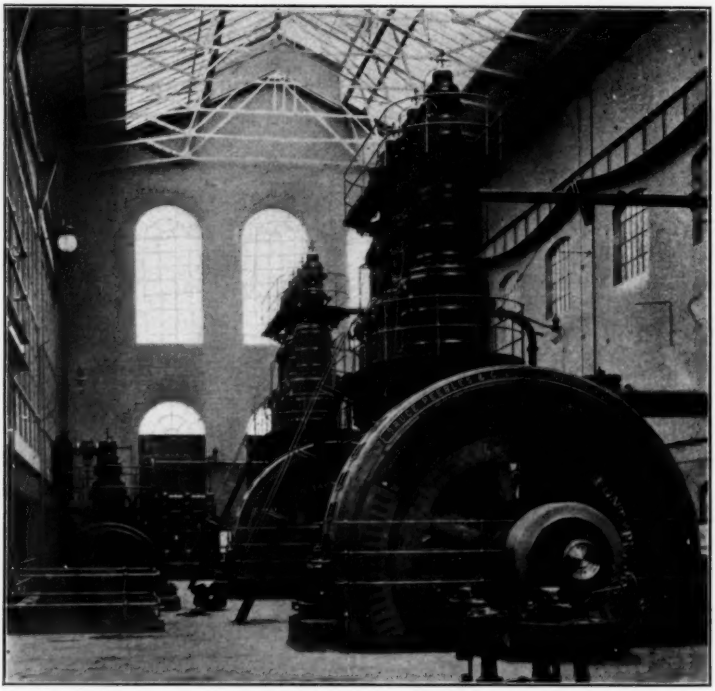
periods and a pressure of 11,000 volts between each two conductors. The current is led to sub-stations, the interior of one of which is shown on p. 771, where the pressure is let down to that needed for working motors in collieries and factories. The working of the mains has been singularly successful and free from trouble. Wattstown,



INTERIOR OF CARVILLE POWER STATION, NEWCASTLE ELECTRIC SUPPLY COMPANY.
Showing 7,000-horse-power turbo-alternator by C. A. Parsons & Co., Newcastle-on-Tyne.

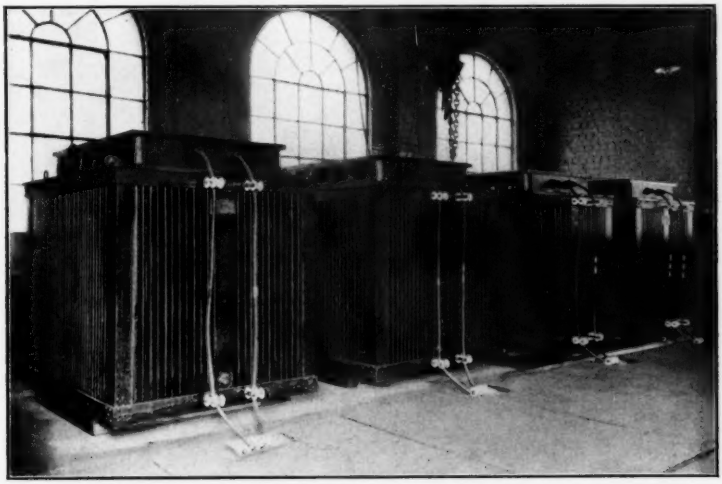
which is nine miles from the station, has been regularly supplied since last March; the Cambrian Colliery, at a distance of eleven miles, since last June; and the Glamorgan Colliery, which is ten miles from the works, since last August. A drawing showing a section of the cable with which these results have been obtained is given on p. 768.

Although there was a good deal of anxiety for some time as to whether the large collieries in the district would take current from an outside source in preference to generating it themselves, the results up to date have more than justified the confidence of the promoters. Although the station has not yet been running a year, orders for supply to the extent of over 11,000 horse power have been actually secured, negociations are proceeding regarding an additional 19,000 horse power, and enquiries have been received as to about 30,000 horse power further, a good deal of which is certain to result in business.



PONTYPRIDD POWER STATION, SHOWING PART OF THE GENERATING PLANT.

As showing the class of business obtained, the following particulars of power being supplied to various collieries may be interesting: United National, Wattstown, 710 horse power; Glamorgan Coal Company, Llwynypia, 800 horse power; Cambrian, Clydach Vale, 185 horse power; Lewis Merthyr, Hafod, 374 horse power; Albion, Pontypridd, 800 horse power; New Windsor, Aber, 417 horse power. A further contract covering the initial supply of 2,200 horse power to one colliery undertaking has also been concluded. In most of these cases, further orders for plants have been or are being placed, or are contemplated, and additional customers or applications for supply are being continually received.

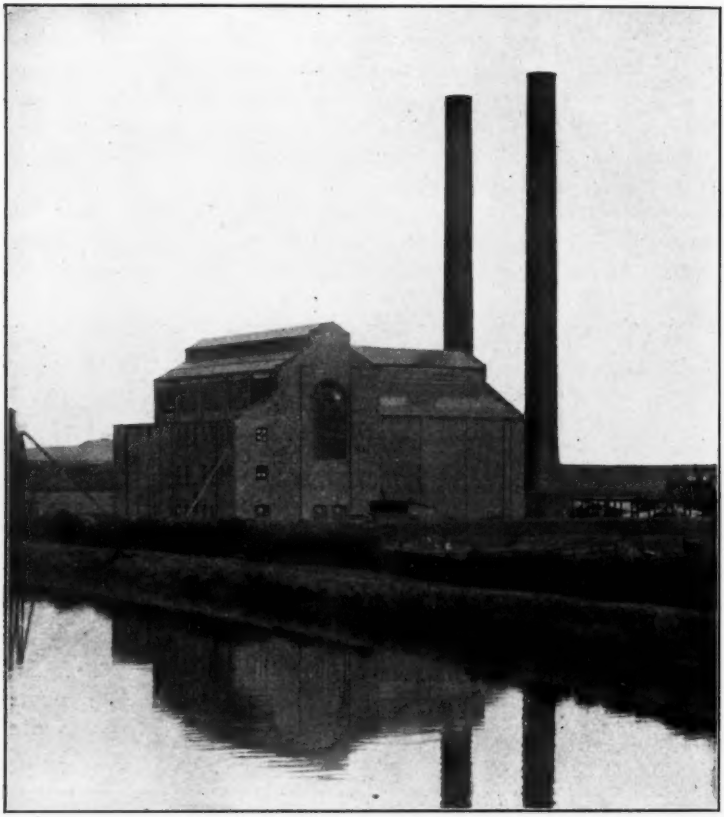


A SUB-STATION OF THE SOUTH WALES ELECTRICAL POWER DISTRIBUTION CO.

The capital so far subscribed consists of £450,000 in ordinary shares and £150,000 in debentures, but to meet the continually increasing demand for power, a further issue will have to be arranged during present year.

The next companies demanding notice are a group of three, whose first power stations are all on the verge of completion and which will all probably be supplying energy before this article is in the hands of readers.

The first of these both as to the date of its act and as to the importance of its area is the Lancashire Power Company. The act when obtained, however, needed a great deal of negociation work with local authorities before it could be applied with commercial

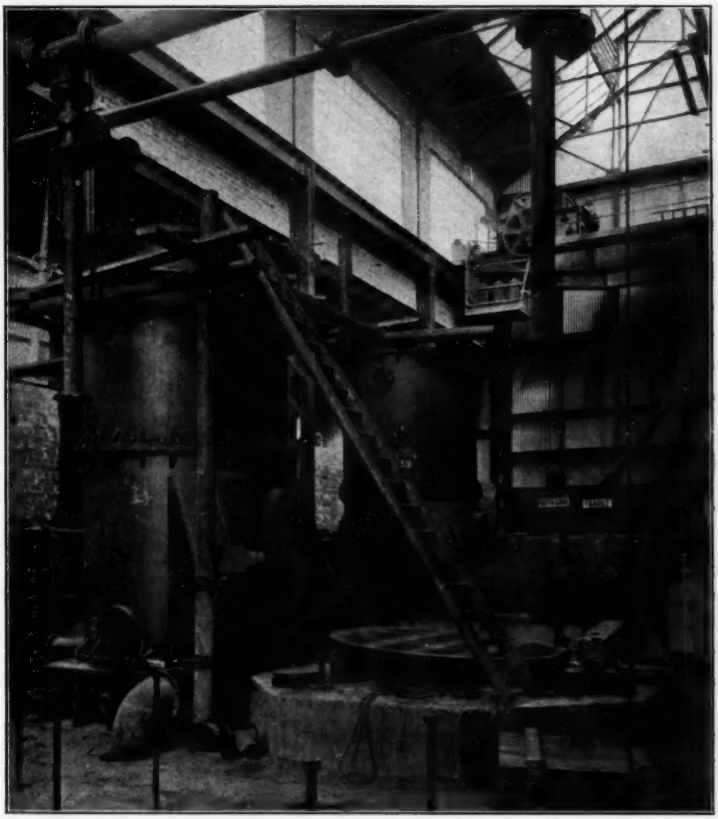


THORNHILL POWER STATION, YORKSHIRE ELECTRIC POWER COMPANY.

success. This has in the interval since the passing of the act been in a great measure accomplished, and the company was privately capitalized to the extent of about £300,000 some eighteen months since. The initiative in the matter was largely taken by what is known as the "Edmundson group," who have been so successful in dealing with the lighting of a number of moderate sized and small towns. The directorate is a very strong one, and the area has within it steam engines now in use totalling over 1,000,000 horse power. There is, therefore, plenty of scope for business as soon as the dog-in-the-manger policy of the local authorities is surmounted,. which the trend of public opinion makes more and more likely.

The Lancashire Company is just completing its first station on a site near Bolton, which is to contain initial plant capable of supplying about 6,000 horse power at 11,000 volts and 50 periods, three-phase. The prime movers are to be Curtis turbines, and the station is almost a fac-simile of that of the Yorkshire Electric Power Company which will next be noticed and a photograph of whose station at Thornhill is reproduced herewith.

The Yorkshire power act is on much the same lines as that of the Lancashire Company and since it was obtained has called for much negociation with local authorities to get a clear field. Good progress



INTERIOR OF THORNHILL POWER STATION. GENERATING PLANT IN COURSE OF ERECTION.

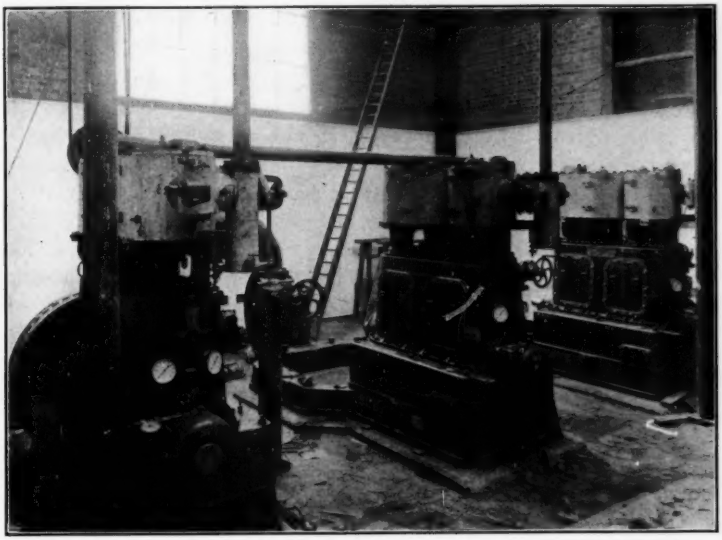
has, however, been made in this direction, and several considerable contracts have already been booked and the prospects are considered very favourable. The Yorkshire Company issued a public prospectus about eighteen months since, but it is an open secret that the greater part of the £300,000 of initial capital has been found by powerful interests who considered the undertaking worthy of the necessary support in its initial stages. The Thornhill station will contain about 6,000 horse power of plant available to commence with, and its supply will be three-phase at 11,000 volts and 50 periods.

The third of this group of companies is the Clyde Valley Electrical Power Company, which hold powers over the rich area having Glasgow for its centre, though the company is excluded from operating in Glasgow itself and in some of the other large towns in its area.

Shortly after its act was obtained, this company allied itself with a financial group in close touch with the British Westinghouse Company, and so far no attempt has been made to obtain finance from outside sources. The subscribed capital is about £600,000, which is gradually being paid up as needed. Two power houses are under construction and near completion, one at Yoker and one at Motherwell; they are each intended to have a capacity of about 13,000 horse power, with arrangements for extensions. Westinghouse-Parsons turbo-alternators are to be used for generating the current, which is to be three-phase at 11,000 volts and 25 periods. There are in the area a great number of steam engines now in operation, and the company hopes to dispose of a large amount of electrical energy in replacing these, and otherwise.

Besides the above companies, the County of Durham Company, the Cleveland & Durham Company, the Nottinghamshire & Derbyshire Company, the Fife Company, and the Scottish Central Company have all started works to deal with certain portions of their areas. These works are as yet on a smaller scale than the above, but they are designed for extension later, as soon as the possibilities of power supply are more generally appreciated and capital can be secured for operations on a more extended scale.

Another interesting company is the Metropolitan Electric Power Company, which has obtained powers to supply electric energy in bulk over an extended area to the north and east of London and which has recently completed a very up-to-date generating station at Brimsdown, near Enfield. The initial plant consists of three 1,000-kilowatt Parsons turbo-generator sets supplying three-phase cur-



INTERIOR OF THORNHILL STATION, YORKSHIRE ELECTRIC POWER COMPANY.

rent at 11,000 volts and 50 periods, chiefly, so far, for tramway supply and for supply in bulk for lighting certain areas.

In the case of several of the other companies which have not been specifically noticed, arrangements are in an advanced position for making an early commencement of operations. It will thus be seen that on the whole the movement is rapidly developing, and with the advent of better times and greater confidence amongst investors each success will undoubtedly be followed by further developments, since none of the power companies, even those which have put up the largest generating stations, can yet supply more than about 10 per cent. of the horse power within reach of the mains from the stations they have so far erected.

In this connection, it is important to observe that the work of power companies will grow by what they feed on—that is, as they become larger they will be able to supply at progressively diminishing rates of cost, and therefore the larger they grow the lower prices will they be able to charge and the larger will be the proportion of the total power utilized within the district that can be economically supplied from their mains in preference to local generation. I have endeavoured to deal with this aspect of the subject in an article in *Engineering* to which readers must be referred for further detail.

One of the most complicated subjects to be dealt with in power supply is found to be the question of making a fair and equitable arrangement with the consumer—that is, to give the consumer all the advantages that can be given and at the same time to secure that the power company is properly remunerated under all circumstances for the work it does. Agreements with power consumers may vary in value from a few pounds per annum up to several thousands. When they approach the latter figures, very slight alterations in the tariff or in the way it is applied may mean differences of very substantial sums. Moreover, it is often very difficult at present to get a customer to understand the real nature of such an agreement and what is the true operation of the different clauses. Of course, all these obstacles are incidental to the development of a great new industry and need much thought on the part of those who are interested in it, but such things straighten themselves out in time and become the taking-off point for further advances. The question of price as related to the hours of use per diem and per annum, it may be pointed out, is of relatively more importance in a station operated by steam than where there is a perpetual water power which, during a good part of the day, would run to waste if the load did not utilize it to the full. Broadly speaking, most of the companies are basing their prices on a sort of double sliding scale, in which the price is made to decrease—firstly, as the current is used for longer periods per diem or per annum beyond a certain fixed minimum, and again a further series of discounts being given as the total quantity of energy taken per quarter increases. Thus a long-hour consumer who takes a large horse power secures a double advantage. Further reductions in addition to these are in some cases offered when the customer will agree to shut off his power supply during the two or three hours when the load is heaviest on the station, employing it only at other times. This can often be managed in the case of mine pumping. Besides these factors, agreements have often also to embody special arrangements, as to bringing the mains to the customer, the length of time for which the agreement is to run, and certain other points. It will thus be seen that the making of fair arrangements with customers is by no means a simple affair, especially to start with, though as soon as people understand clearly the principles on which agreements of this kind are based negociation becomes much easier.

In connection with the supply of consumers with electric energy, the selling of motors and other appliances to them on hire-purchase terms is already becoming a considerable business and one which is

likely to develop greatly, as it helps the power company to increase its load quickly and the customer can call on the power company or some allied institution to keep his electrical apparatus and plant in order and to see that it works efficiently.

Distribution by the power companies has hitherto been entirely by means of cables laid underground, but as the Board of Trade has now relaxed the ridiculous restrictions on overhead transmission, which have so long held back the electrical industry in Great Britain, it is practically certain that this latter method of transmission will gradually come largely into use in the future, at any rate for transmitting energy to long distances and for serving the less rich and more scattered districts within the areas of the power companies.

Such, then, is approximately the present position of what are called colloquially "the power companies" in Great Britain. It remains to say a few words on their future prospects. I have already indicated the belief that their future will be a considerable one in any event. The power companies which have started are up to the present exploiting only the richest parts of their areas, and the plant so far being laid down cannot on an average replace much more than a tenth part of the horse power of engines already at work in the areas which can be reached from the stations already erected or being erected. Most of the areas of the different power companies moreover, will need three or four power stations to cover their areas, if the present supply pressure of 11,000 volts is adhered to. Even supposing that supply by the power companies does not replace anything beyond the smaller engines, and only comes in where electric driving is specially suitable, all the power companies have room for large extensions. If, however, as seems probable from the way things are going, as the power companies increase the size of their undertakings they are able to reduce their prices—and further developments and improvements will enormously help towards this end,—it is hard to assign a limit to the amount of power which they may ultimately supply in their different areas, particularly considering that there is likely to be a great growth in the use of power altogether when once it can be obtained so readily, in such an available form and on such moderate terms. Further, the power companies will probably supply large quantities of energy in their respective areas for driving tramways and inter-urban railways, for lighting, and later on possibly for heating and ventilating purposes. Finally, it is quite possible that if railway electrification comes about, the railway companies in many districts may find it advantageous to come

to some working arrangement with the local power companies rather than to set up isolated power stations for themselves.

To say more would be to enter into the region of romance. I will therefore end with only one further remark. During the last quarter of a century the problem of electric generation, transmission, and utilisation has been the focus round which the more practical physicists and the more scientific engineers have concentrated their efforts. There is still room for an immense amount of work in the same direction, but so much has been done already that there is evidence that the more ardent spirits are beginning to look a step further back. It seems as if the great central physical and engineering problem of the next quarter of a century would be the more economical production of energy from coal and the liquid hydrocarbons; that is, efforts will be concentrated on improving the steam engine, the gas engine, the oil engine, and probably the gas turbine, or possibly some new form of prime mover, with the object of attaching them to the already highly efficient electric generators, transmission line, and motors, lamps, or heating appliances. During the last few years great advances have already been made in improving the thermal efficiency of prime movers. With our present knowledge and appliances, with the means of accurate testing which the coupling of an engine to a dynamo gives, with great power stations managed by highly skilled and technical staffs to look after the plant required, who shall say by how much the efficiency of engines or prime movers may not be improved within the next twenty-five years? Is it impossible that within that time or, say, within the next half-century, the efficiency with which the energy in a pound of coal can be turned into electric energy may approach 60 per cent.? Should even 50 per cent. be attained, how profoundly, considering the ease with which energy can be transmitted, would such a state of things modify not merely the method of carrying on industries, but the daily life of all who live in civilized and populous communities!

Such possibilities there are in the future. The mission of electric-power supply is in any case a beneficient one, bringing health and brightness by the banishment of smoke and dirt, in addition to the positive economies and facilities it places at our doors. Much remains still to be done, but a solid groundwork has been laid and continued progress may reasonably be looked for.

MINING AND HYDRAULIC ENGINEERING IN BRAZIL.

*By William Maude.**

The engineer in charge of the work described in the following article is a man of international reputation and of wide experience in public affairs. The work, while not heavy nor extensive in itself, is interesting on account of its peculiar and novel surroundings, which are excellently portrayed by the author.—THE EDITORS.

A COMMUNICATION from the province of Minhas Geraes, Brazil, gives the following interesting account of engineering operations in that remote locality.

The operations were designed:—I, to supply an auriferous placer, or *cata* ("quarry") near San Gonzalo with a volume and head of water capable of breaking down and washing a bank of auriferous gravel, 50 to 100 feet in height; II, to supply an adjacent town with an equal volume of water for domestic purposes, from a different source; for the sake of avoiding repetition, only the former one of the two hydraulic operations will be described in this paper; III, to work the *cata* and extract the gold by the American hydraulic process.

The engineers to whom these operations were committed, having first made a survey and map of the locality, repaired to England, where the plans were drawn and the pipes, and other machinery and supplies needed for the works, were ordered and constructed under their directions. These materials were shipped by steamer from Southampton, while the engineers themselves proceeded to Brazil by the more expeditious route, via Bordeaux. They arrived at Rio in time to make arrangements for the prompt transportation of their ponderous material to the interior, so that when it arrived at Rio, no time was lost; it was passed by the customs officials and at once transferred to the railway, which was to carry it about half the distance to its ultimate destination. It is deemed useful to allude to these details, for the reason that engineering operations in Brazil are often ruinously delayed or entirely defeated by lack of attention to them.

At the terminus of the railway line the "machinery"—for so was it classified, invoiced, and passed at the custom-house—was trans-

* Translator of Humboldt's "Fluctuations of Gold," etc.

ferred to bullock-carts, the only means of transportation to its destination; and as the shape and capacity of these vehicles, both of which are due to the condition of the roads, have a practical relation to all engineering operations in the interior of Brazil, it is necessary to allude briefly to them. The roads into Minhas were built in the early part of the 18th century, when the placer mines were most productive. They were of the Roman pattern, about 16 feet wide and paved with cubical stones, each weighing about a quintal, or more than twice the size and weight of those now employed in paving the great thoroughfares of New York. So long as the mines continued to remain productive—and this means productive on the basis of slave-labor—these roads were kept in repair. When this period was passed, that is to say during the latter half of the 18th century, the roads were neglected and the elements have since that time had entire control of them. The result is that the prominent portions are washed away, the depressed portions are converted into morasses, and the level portions obstructed with blocks of stones washed from above, over which obstructions nothing except a bullock-cart can be dragged, without destruction.

These vehicles consist of a strong platform shaped something like a mason's trowel, except that the tail does not taper to a point; the handle of the trowel representing the tongue or pole of the cart, on each side of which is yoked a powerful ox. The platform is mounted upon an axle joining two solid wooden wheels, all bound together into one piece; so that, like the mechanism of a railway carriage, the axle turns with the wheels. The latter are of course shod with iron and made as strong as possible, any breakdown upon roads destitute of smithies being equivalent to a calamity. The vehicle thus described will bear a burden of about half a ton and, when fully laden, it is usually hauled by four or six yoke of oxen. They go very slowly, making about ten to twelve miles a day, but nothing short of a precipice can stop them. The size and shape of the platform and the almost precipitous grades of the road, which the car has sometimes to surmount, determine the weight and dimensions of the load. Heavy machinery is out of question. Bulky parcels are difficult. Long ones would strike the ground in ascending. Lofty ones would strike the trees.

The *cata* to be worked was a relic of the 17th century, situated several hundred miles northwest of the capital. At the head of a valley some thirty odd miles long and six miles wide stands the town of Campanha, below which at some distance courses the river

TYPE OF WATER BOX AT THE HEAD OF THE LINE.

Sapucahy. This valley is walled in on either side by a range of mountains originally composed of granite, gneiss, ferruginous gravel, and lava, in the order named. In most places time and the elements have washed away the lava and gravel, and covered the gneiss with vegetation; the lava and gravel, both reduced almost to the fineness of powder, being redeposited below in the form of rolling hillocks, which constitute what may be termed the floor of the valley.

About midway betwen Campanha and the river, and a short distance east of San Gonzalo, these hillocks are higher than elsewhere, and form a watershed, which throws all the water on the Campanha side into the Palmella and this into the Verdi; while on the San Gonzalo side it all flows into the Sapucahy. Thus, what the mountains made into one valley, the hills have made into two valleys; and as all the material of this double valley is more or less auriferous, Campanha became a mining centre as well as San Gonzalo, though scarce-

THE PIPE LINE FOLLOWING THE BOTTOM OF A CANYON.

ly of the same importance at any time, and not nearly of equal interest at present.

The principal sources of water—without an abundance of which hydraulic mining is impracticable—are the *Mai d' Aguas* (Mother of Waters) in the Northern Sierras, and the Santa Rita, in the Southern Sierras; the former a bubbling spring of about 15 miners' inches, and the latter a cataract of 3,000 inches; the former at an altitude of 600 feet above the crest of the hill beneath which was the *cata* to be worked. This was the stream which, for reasons of expediency, it was designed to impound. Before describing this work, it may be of interest to relate the manner in which a branch of this same water was utilized by the miners of two centuries ago.

The distance on the map or horizontal distance between the spring and the *cata* does not exceed eight miles, but as the surface on this line first falls 1,800 feet and afterwards rises 1,200 feet, the water, if conveyed from one to the other in open ditches, has to

THE LINE IN A HILLY SECTION.

make a detour of nearly 30 miles, winding along the flanks of mountains and over saddles of hills, losing grade at almost every turn and finally centering near San Gonzalo, with a branch to Campanha.

Under the ancient Portuguese system of mining, the auriferous earth was not broken down by hydraulic jets, but by *cavaderas* (pikes, or lances,) and other laborious means. Hence no greater altitude was required for the ditch lines than was sufficient to conduct the water to the brow of the *cata.* The loss of grade in the ditches was therefore, unimportant. To the modern hydraulic miner, the loss of grade is of the utmost consequence. It involves either the making of new ditches at much greater altitudes (not always practicable, on account of the inferior height of some of the intermediate hills,) or else the use of iron pipes. Besides ditches, the waterworks of the Portuguese consisted of *tanges* (reservoirs) to store up the water running during the night, several of which were near San Gonzalo, with the appearance, to the unprofessional eye, of natural

PIPE LINE ON THE PLATEAU, NEAR THE TERMINUS.

lakes. The dams were covered with dense thickets and numerous trees, while the ground below the dams was raised by the debris of the surrounding *catas* and covered with vegetation. Water-fowl and edible fishes abounded in these lakes and served to conceal still further the nature of their origin.

Six series of mines—Bahu, Samambaia, Santa Cruz, Funda, Escuro, and Paciencia—comprising hundreds of separate *catas,* were opened in this vicinity during the 17th and 18th centuries; and a town naturally grew up in the midst of them, San Gonzalo being actually enclosed betwen Santa Cruz, Funda, and Escuro. Where the red and yellow banks of Santa Cruz face the spectator, he has only to walk a few steps to cross the wooden bridge which spans the ancient sluiceway of Cata Funda; while he has only to turn back a few other steps to gaze upon the abandoned opening of Cata Escuro, where captive Indians were once worked to death, and negro slaves entombed alive.

Originally, the drainage of the valley west of the watershed flowed past San Gonzalo into the Sapucahy, at a level some 50 or 60 feet below that of the town; but a century of debris so filled up the *corrego* (sluice-way) that the town now stands but little above the water, between which and its main street lies a *praira* (shore) about 200 feet wide and shelving down some 15 or 20 feet. There must have been a time when the *corrego* washed the garden walls of the houses; but since that time the water has cut its way down through the deposit of tailings and exposed some 10 or 15 feet of its numberless layers.

The ancient system of mining was either to break down the earth with long pikes, or with the series of water-holes mentioned farther on. It was then concentrated in ground sluices and the gold recovered from the concentrations by panning. There are but few evidences of flumes, sluice boxes, riffles, or the use of mercury for amalgamation. As there were no saw-mills, and hand-saws were scarce, but little lumber was cut, and that almost altogether with the axe and adze. Hence flumes and sluice boxes can hardly have been used. Yet in one place there is a mine called *Andaime,* which means a flume, and which was evidently so named because a wooden flume was employed to carry the water over a small chasm. Mercury, or quicksilver, was a government monopoly, and very costly. Iron pipes, owing to distance and the absence of railways, were out of question. These circumstances, coupled with the fact that blankets were sometimes used in the ground sluices, indicate that the miners of past ages were prevented from developing their system up to the phase of "hydraulicking," only by lack of materials and mechanical resources. On the other hand, the Indian *cautivos* (captives) only cost the price of enough food to keep them alive; while their successors, the African slaves, could be landed on the spot for, at most, $50 each. So long as human labor was comparatively costless, panning was superior to sluice boxes and mercury; and as this was the case for two centuries after the placers were discovered, it follows that but few districts known to be auriferous were abandoned, until either the best spots were washed down, or the entire vicinity was run out of grade, and so rendered valueless to anybody except the individual free panner.

Among the ancient devices for breaking down the auriferous earth was one which was used by the Romans in Northern Spain: that of cutting a ditch or sinking a line of holes along the edge of a precipice and saturating them with water until the "face" gave way

and a "caving" or landslide occurred. Marks of this device can still be seen in some of the *catas* mentioned. With such primitive appliances and devices the sacrifice of human life must have been appalling, especially when we are informed, upon the authority of the Abbé Raynal, Baron von Humboldt, Dr. Southey, and Mr. Mawe, that during the two centuries of their productive period the placers of Brazil yielded no less than a thousand million dollars worth of gold. After paying the Quinto, or royalty of a fifth to the Crown, most of this treasure went to Lisbon, where the mint laws exacted another tribute from it; then it found its way, in trade, largely under the operation of the Methuen Treaty, to England, where it laid the foundation of the mint laws which distinguish the Hanoverian period.

So much for the past; now for the present. The altitude of the spring, whose waters were to be conveyed to the mine, was about 6,500 feet above sea-level. From this point, where a water box was constructed, the pipe line passed down through a rocky defile or canyon to a gravel plateau 1,800 feet below. Thence it proceeded for a distance of two or three miles upon more or less level ground to the base of a series of irregular hills, up which it had to climb to a vertical height of 1,200 feet above the plateau, to a point which will be called the Crest. At this point, the pressure of water, less friction, would amount to 600 feet. The portion designed for immediate use was to be employed 50 to 100 feet below the Crest. The net pressure at the point of discharge, leaving friction out of view, was therefore 650 to 700 feet. The total length of the line was eight miles. Through the rocky defile and until it struck gravel, the line had to be laid above ground. When it reached the plateau, and upward, in many places, until near the Crest, it was buried; in order to place it beyond the reach of accident or mischief.

The pipe line commenced in 6-inch and ended in 4-inch "steel" pipe, with screw joints. So soon as the pipe began to arrive on the ground, a difficulty presented itself which had been only partially foreseen, or provided for, in the estimates of expense. This was the necessity of clearing the timber, and building temporary roads, to enable the pipe to be conveyed to the spot upon, or under, which it was to be laid. The expense which this work involved and the time lost in executing it proved to be far more than was anticipated.

Another difficulty occurred which was entirely unforeseen; the contractors who furnished the pipe shipped a portion of it with threads cut twelve, and another portion with threads cut eleven, to the inch. As nobody imagined that such an egregious blunder was

likely to be committed, the threads were not counted until the pipe was laid on the ground where it was to be put together; then it was too late to rectify it. To describe the chagrin which this discovery occasioned would be to write a serio-comedy. At first it seemed that the entire enterprise was doomed to ruin. Either the pipe joints had to be shifted, so that the 12-threads would all lie together in a continuous line and the 11-threads in a further continuous line, or else they had to be left where they had been deposited and new threads cut for innumerable joints. After a careful scrutiny of the joints, a distinguishing mark was placed upon the 12-thread joints and a consultation held on the subject, which ended in three notable measures. First, the pipe contractor was forever anathematised and excommunicated; second, a thread-cutting machine was ordered from Rio by express-post; third, the shifting of the joints was commenced. Arduous and expensive as this work proved to be, it was completed before the thread-cutter arrived; so that all the machine had to do was to cut one 12-inch thread upon an 11-inch joint. However, the cutter proved to be useful on other occasions and for other purposes. We learnt two lessons from this bit of experience: 1, count and test your threads before paying for your pipe, or ordering it to be shipped; 2, ship a thread-cutter with it.

A still further difficulty which confronted the constructing engineers is worth alluding to, because it affects engineering operations not only in Brazil, but in most other countries under Roman influence. One of the engineers was informed by influential parties in Rio Janeiro that unless the local ecclesiastical authorities were propitiated, the successful working of the enterprise would be delayed or endangered. Indeed, the information went so far as to intimate that unless such propitiation took a very material form, it would be found impracticable to obtain native labor in the prosecution of the works; and that even if, in spite of this obstacle, the works were carried to completion, the undertakers would have to yield up a substantial portion of such profits as they might earn in operating the property.

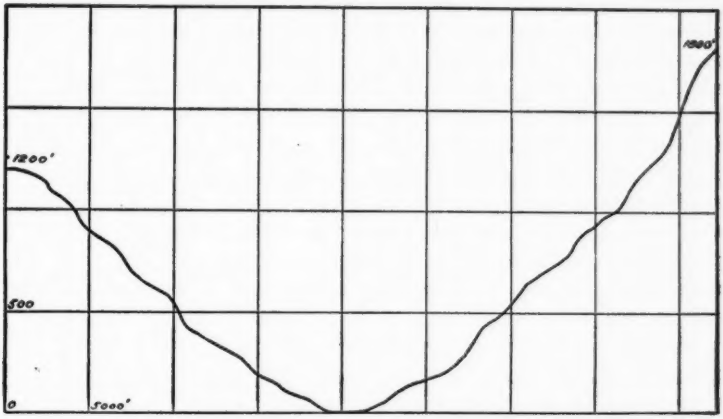
Had these intimations been made before the pipe was shipped from England, it is probable that the enterprise would have been abandoned at the outset. Happily, as it turned out, the pipe was already on its way; and the only course open to the undertakers was to test the accuracy of their information by seeking an interview with the Bishop of the diocese in which the operations were to be conducted. In ten minutes' time, the whole of the bugbear depicted at Rio was dissipated into thin air. The Bishop of Campanha, a

venerable priest, clothed in years and piety, so far from opposing the enterprise, willingly offered it all the support in his power. He not only disclaimed any wish or intention to impede or tax it; he declared that such a course would be both ruinous to the diocese and impracticable.

"These works," said the Bishop, "will prove a godsend to this community. They will bring to these long neglected *catas* the only power than can revive their productiveness—the power of machinery and improved methods. They will remuneratively employ a number of my parishioners, who now are idle for lack of modern tools, and indigent from the absence of industrial capital with which to erect proper works and give the people employment. As for taxing enterprises so much-needed, even were the mad desire entertained, it would be impracticable. My parishioners are Catholics; they are not slaves. They are free and independent, and very jealous of any interference with their freedom. Any attempt, either on the part of the clergy, or any other power or influence, to interfere with local industrial works, would be resented with indignation and followed by riot. Your influence with the people will be far greater than mine; and, so far from obstructing your operations, I shall take the greatest pleasure and interest in promoting them; and of this, I will afford you the strongest proofs, should you deign to invite me to be present at the installation of your works." The sincerity and goodwill of the aged priest was so evident in what he said and suggested, that all doubts on this head were at once dispelled; and, as the event proved, he not only refrained from any attempt to oppose the enterprise—he materially aided it in many ways; and the same may be said of the inferior clergy. The intimations given out at Rio, all of them from foreign sources, proved to be altogether mistaken.

For purposes of convenience, the profile of the pipe line, now presented, is drawn upon a horizontal scale of 10,000 feet to the inch and a vertical scale of 835 feet to the inch. The quantity of water conveyed by the pipe line (all that could be got at a suitable altitude and without too great expense), would, by itself, have been far too small for breaking down hard gravel or carrying on any hydraulic works that would deserve that name. But as the *catas* were composed of very fine gravel, almost destitute of stones, and as we had the assistance of the old ditch line, which, by a slight diversion was made to deliver a supplementary and copious supply of water to the Crest, the two lines of water-supply together worked with all the effect needed to keep the sluice boxes busy.

When the pipe line neared completion it was arranged to celebrate the occasion by an installation or opening ceremony and a grand lunch, to which the good Bishop and all the magnates and *fazendeiros* of the vicinity, together with their spouses, were invited.



GENERAL PROFILE OF THE PIPE LINE.
Vertical scale, 835 ft. to inch; horizontal, 10,000 ft. to inch.

For this purpose a temporary shed was erected near the *cata*, in the centre of which was placed a long table laden with refreshments. The assemblage was both curious and picturesque. First came the Bishop in a long crimson gown covered with point lace and wearing on his head a richly embroidered cap; then a stout lady in a palanquin, borne by two white mules; then numerous functionaries and planters, both on foot and horseback; many of the latter carrying their ladies behind them, *en pillion, ou coussinet de cheval.* Many of their costumes were of a period long past. It was a veritable assemblage of the middle ages, about which there was nothing to remind one of the flight of time and the appearance of modern improvements, except the long black pipe which lay upon the ground and the formidable looking nozzle or monitor at the tail of it. One had only to turn his back upon these evidences of the present, to fancy himself projected into the days of Villegagnon and the French Huguenots, whom the Admiral Coligny sent to Brazil in the 16th century.

The proceedings opened with a brief address from one of the engineers, who sketched the design and progress of the works and alluded to the hopes entertained by the proprietors that the undertak-

ing would prove not only profitable to themselves, but also beneficial to the neighborhood. The other engineers followed in similar strains. These addresses, though warmly applauded, sank into insignificance when compared with the speech of the Bishop, and the furore it occasioned. The venerable prelate not only applauded and confirmed all that had been advanced by those who had preceeded him; he drew a strong picture of the desolation which had fallen upon the mines since their ancient abandonment, the decay of the mining towns, the neglect of the roads, and the isolation and poverty of the surrounding communities. Then, turning to the engineers, he pointed to them and to their works as the hope of the future; and entreated the assemblage to lend to them all their good-will and influence; because, to do so was to help the poor, build up the neighborhood, and supplant want and misery with prosperity and happiness. The good old man was so much affected by his own pictures of the local distress and by the fervent hope that it would be relieved through the agency of the new works, that he was melted into tears; and throwing his arms around the neck of one of the engineers, he asked him, in the name of all that was good and charitable, to open the works with his blessing. The *vivas* which greeted this outburst of feeling gave ample assurance of the approbation which the works were destined to gain from the bystanders.

At a signal which had been arranged beforehand, the water had been turned on and soon came tumbling over the Crest from the ditch line and bursting through a 1½-inch nozzle from the pipe line; the latter throwing up a magnificent *jet d'eau* and illustrating its tremendous power by undermining the *cata* and letting down vast banks of auriferous sand and gravel into the ground sluices and boxes. Upon the commencement of this exhibition the Bishop piously blessed the pipes, and the attendants chanted a hymn in which all hands joined, while some of the bystanders fired off pistols and rockets. It became a veritable *dia de festa,* a general jubilee; and nobody seemed more delighted with the performances than the aged priest, whom, it had been mistakingly feared, would bring a blight upon them.

After the monitor had been made to perform all sorts of curious antics, such as knocking down a shanty, plowing up a channel in the ground, etc., the company adjourned to the improvised banqueting hall, to discuss such good fare as the hosts were able to obtain in the neighborhood. This was as strange as the costumes and other surroundings of the occasion. Country cheese and country wine; canned

kippers from England; canned butter from Italy; some ancient Spanish *bacalao* (dried cod-fish), discovered by accident in a grocer's forgotten cupboard and now served in a stew with native onions, "chili" and canned tomatoes (pronounced "perfect" by the Bishop); some English canned cakes and biscuits; and—more esteemed than anything else, at least by the gentlemen—a profuse supply of Bass' pale ale, or "pally-ally." These delicacies, together with coffee and segars, made a feast which all hands declared to be superb.

On the following day, work was commenced in earnest; and though some interruptions occurred, owing to the inexperience and awkwardness of the laborers and to some other circumstances, it was continued, until success crowned the efforts of the undertakers. One interruption to the enterprise was of so singular a character as to merit especial mention. By direction of the undertakers, wooden posts were driven into the ground around the *cata* and a rope was stretched over them, in order to secure the works from intrusion on the part of idlers. Placards were also posted up, warning such persons to keep off. On the third or fourth day after the operations commenced, a huge native, with a spear in his hand, leaped over the cordon, and made his way to the sluice boxes, which he narrowly inspected. One of the engineers, an old time Californian, immediately confronted him and pointing to the placards, requested him to withdraw. The giant with the spear thereupon drew himself up to his full height, planted the shaft of his weapon on the ground, struck a Roman attitude, and declared that as the land belonged to him, he hadn't the slightest intention to withdraw, but on the contrary, wanted to know what they were doing with "his property." This led to an altercation, in which it appeared that the giant's forefathers had formerly worked the *cata* with slave labor, and had not since then parted with their title, which now had descended to him, the man with the spear. On the other hand, the engineer showed that the *cata* belonged to the Brazilian government, which had only permitted the big man's ancestors to work it; that upon ceasing to work it, the *cata* reverted to the government, which had now accorded a like permission to the new undertakers. This permit (a formal patent in writing, conceding the right to mine) was exhibited to the interloper, with a very strong repetition of the request to withdraw. But the big man stood his ground; and it was only after some rather forcible argument that he was persuaded to betake himself and his spear to the other side of the ropes. This of course meant future trouble; and, as a means of averting it, a consultation was held be-

tween the engineers, at which it was determined, rather than run any risk of interrupting the works, to buy off the claimant; the sum of £200, in Bank of England notes, equal to 4,000 or 5,000 milreis, being appropriated for the purpose. The Californian, armed with these notes, was deputed to conduct the negotiation. On the following day, to the surprise of everybody, these two mortal foes, the man with the spear and the man who tossed him over the ropes, were seen in the village café, hobnobbing together, apparently the best of friends, one having laid aside his spear and the other his revolver. It seems that a written treaty had that day been entered into between them, by virtue of which, and in consideration of a certain sum of money, "the receipt whereof is hereby acknowledged," the native had cheerfully yielded all claims to the *cata* in dispute, as well to all other *catas* in the vicinity; and though we were burning to know what consideration had been agreed upon, we refrained for the present from interrupting so amicable and joyous a reconciliation. After the Californian had parted with his newly found friend, we all rushed into the café, anxious to learn the terms of the treaty. The information astounded us. The negociant had bought off the belligerent native for a few refreshments and the inconsiderable sum of five pounds; and he at once returned the balance into the treasury. "California style," he observed, sententiously.

One word more. It is a common error of those who know nothing of Brazil to imagine that the climate is unbearably hot, that the roads are unsafe and the natives treacherous. The facts are that after leaving the lowlands of the coast, the general level of the country being from a quarter to half a mile above sea-level, the air is pure and the climate bracing. We wore the same kind of clothing that we did in England during corresponding seasons of the year. The roads are rough, but not unsafe; while the people are so inoffensive that, after a short experience with them and barring the one contentious character alluded to herein, we never deemed it essential to carry arms.

CARE AND CONTROL OF THE SMALL-TOOL EQUIPMENT IN THE SHOP.

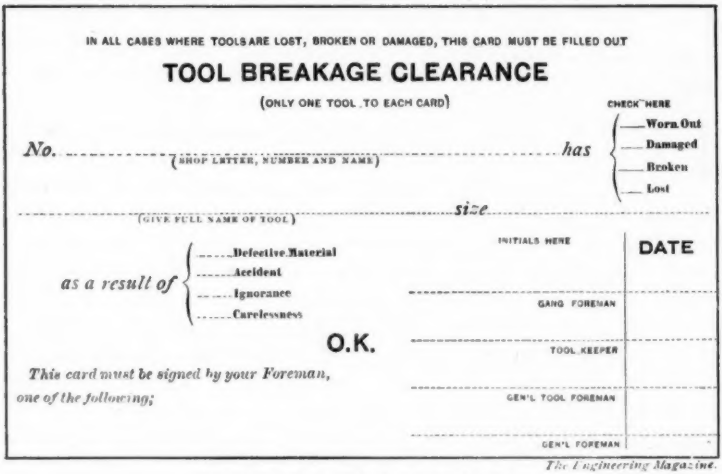
By R. Emerson.

In our issue of December last, Mr. Emerson presented the first section of his discussion of "Tool-Room Practice for a Railway Repair Shop." In this he dealt with the general policy of standardization and organization of the tool management. Following the same general lines, he now deals with the care and upkeep of the small-tool equipment. While the experience on which his system is developed relates to the railway shop, the general ideas and special forms are adaptable to works of any kind.—THE EDITORS.

I DO not know of any more expensive item than twist drills. These tools produce more work for their weight than any other tool, but on account of the intensity with which they are worked and the few lines in which they are unproductive (who ever heard tell of a shop that had more than enough of the commonly used sizes of twist drills?) their life is extremely short; and as the tool is not especially cheap, the amount of money annually sunk in this one item is very great—easily from a dollar to two dollars per year for every man of any kind in the mechanical or motive-power department of the road. The destruction of these tools will be the greater according as the drill work is pushed; in other words, if the drilling department should increase its efficiency 50 per cent., the destruction of drills might easily increase 150 per cent., and yet this would be true economy, because the cost of the drills in comparison to the rate per hour of the men is so small as to make the saving in wages many times overbalance the increased tool account. Although the destruction of drills is always great, and may be legitimate even when on an extensive scale, nevertheless proper methods may be devised whereby considerable savings can be effected without shortening the tool capacity. For instance, a twist drill will drill better, longer, more quickly, and more evenly if it is properly ground, and ground not only once in every few days, but, if the work on it is crowding, every hour or so.

In order to accomplish this a regular grinding department must be established in connection with the tool room, and a system whereby a dulled or burnt drill may be very quickly exchanged for one in good condition. The good drills should be constantly kept available and the dulled ones ground as fast as they come in. Not only this, but the men on the machines should be prevented from going to the grind-

stone and touching up their own drills. However, it need not be insisted here that a drill ground by hand has not as perfect and efficient an edge as one turned out on a grinder. If drill work is heavy, not only will the edges give out in the natural course of events, but there will be a large proportion of absolute breakages; unless care is exercised, this proportion is apt to be too high. In order to watch this, records of breakages must be kept and it may be convenient to do this in the following manner:—



IN ALL CASES WHERE TOOLS ARE LOST, BROKEN OR DAMAGED, THIS CARD MUST BE FILLED OUT

TOOL BREAKAGE CLEARANCE

(ONLY ONE TOOL TO EACH CARD)

CHECK HERE
- Worn Out
- Damaged
- Broken
- Lost

No. ..... (SHOP LETTER, NUMBER AND NAME) ..... *has*

..... (GIVE FULL NAME OF TOOL) ..... *size*

as a result of
- Defective Material
- Accident
- Ignorance
- Carelessness

INITIALS HERE | DATE

GANG FOREMAN

TOOL KEEPER

GEN'L TOOL FOREMAN

GEN'L FOREMAN

O.K.

This card must be signed by your Foreman, one of the following;

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FORM OF TOOL-BREAKAGE CLEARANCE.

To be filled out by the workman, checked by foreman, and presented with the broken tool at the tool-room window as voucher for the issue of a new tool. The "clearance" forms are filed for record, and periodically examined by the tool-room foreman. The original is 6 by 4 inches in size.

To refuse to receive at the tool-room window a broken drill without a printed form being filled out giving an explanation of the cause, etc., of the breakage, this form to be checked by the man's foreman. On presentation of this with a broken tool, a new tool is issued in its place without question. The record slip is filed, and periodically the tool-room foreman goes over the collection of these slips, tabulates the results, and finds out where and how his drills are being eaten up. He is thus in a position to know not only how much money is actually destroyed in this way, but also what things are the principal cause of this destruction and where reforms may be more easily commenced. For instance, hard castings may be responsible; or, if one man is turning up too many breakages, either his ignorance or his careless-

ness may be at fault. Perhaps the drill is not withdrawn from its hole in the proper manner. At any rate, between the tool-room foreman and the foreman of the work where the principle destruction is taking place, some means of cutting down unnecessary breakage can certainly be devised if these men are after their jobs.

I have taken twist drills only as an example. What is true of them holds true of the other tools—reamers, taps, dies, and very especially pneumatic tools. The forms suggested in the case of twist drills can be adapted to all cases. Opposite is submitted a form for this purpose:

As has been said, the important saving of an adequate tool system lies in the convenience and hence the time of the men, so that, no matter what the wage system, more time is given to actual productive work in proportion to the total number of hours that a man is in the shop than in the case where the workman is hampered by the lack of proper tools or the difficulty of obtaining the use of them. Before the complication of modern machinery and the exacting requirements of manufacture to interchangeable standards, the varieties and sizes of hand tools were limited in number so that it was possible for a skilled mechanic to own nearly all the tools he would be required to use; and in fact he did own them, and took pride in their good condition, which consisted not so much in accuracy of size as in the maintenance of efficient cutting edges. But the modern shop, with its need of using tools and methods that will turn out the work in the least possible time, demands an outfit in sizes and styles of tools, not to speak of templets, jigs, and special devices, representing an outlay of thousands of dollars and requiring thousands of cubic feet for storage. It is manifestly impossible for each mechanic to possess such an outfit containing all the tools he will have frequent need of. Under the old conditions the men pieced out their own equipment by borrowing from their fellows where they had special requirements. At the present time this borrowing is done in large measure from a sort of clearing house—the company tool room. We have, then, three systems existing side-by-side—the individual tool kit, the mechanic's personal property; the loaning of special tools from man to man; and the loaning by the company of high-priced tools for the production of standard sizes in work. There are great advantages in ownership of the tools by the shop; first, in the reduced number of tools required, the tool stores, with an efficient checking and return system, being but a balance in bank to be drawn on from the locality where stringency occurs; second, in the ability to obtain exact standards; third, in the power given the shop management to dictate in detail each process

of doing work, by placing the tools conveniently to the work; and fourth—connected closely with third—by the fact that the workman's wage represents the interest on a smaller capitalized investment—that the man is cheaper and that his output is more closely regulated. It has therefore become the custom in many of our larger and newer shops, not only to supply a company tool-room, but also to furnish to each man such of the simplest tools as it is indispensable he shuld have at hand at all times—hand and cape chisels, hand hammer, files, monkey wrench, center punch, oil can. In less well regulated establishments the man secures these tools as best he may after he enters the company employ, "borrowing" (and keeping) them whenever he has opportunity, and jealously guarding such as he captures, on account of the difficulty of obtaining more; in other shops with more system, the man is required to make a deposit or sign a statement guaranteeing payment in cash to the company for such tools as are lost, a check being maintained on extravagance in this way. Of course, each department of the shop will have somewhat different tool needs, and so the tool kit will vary, the boiler-maker requiring, in addition to the above small list, drifts, calking tools, riveting hammer, and tool box to take with him into the boiler; a machinist will need a large complement of files, a soft hammer, scriber, and several "S" wrenches; a tinner, snips, soldering coppers, pliers, solid punches, square, mallet. It will be found that the cheapest and most efficient way of looking after these tool-kits is to establish at the outset a thorough system providing for all cases with as few exceptions as possible. I shall give an outline of such a system, together with the forms and records used and the way of looking after it. Each man as he enters the employ of the shop is provided with an individual kit of tools such as are needed in the department of the shop where he is to work, kits being uniform within a department; he is provided with a drawer, locker, or cupboard, in which to keep these tools, such storage place being convenient to his work, being made preferably of steel netting for ready inspection, and being provided with a *good* lock of which the tool-room foreman has a master key or duplicate. For all these, key included, a man signs a printed statement that he will return them or their value on quitting the company's service. It is a great practical convenience to have this form confined to a card not over 4 by 6 inches, this last including all the tools that are usually assigned to kits, with blank spaces for extra ones, the tools that are given out in any case being ticked off after each item. It is well also to indicate the cost price of each tool on the face so that a man may know the extent to which he is liable.

Received of North Star R.R. Co,
One kit of tools as follows:

Check here		Cost
•	1½" Chip'g hammer	.30
	1¾" " "	.31
	2" " "	.32
• • •	Cape chisels	.13
• •	Flat "	.13
• •	Rd. nose "	.25
•	Center punch	.08
•	15" Monkey wrench	.85
•	Oil can	.12
•	14" Flat bast'd file	.20
•	14" Sq. " "	.21
•	14" ½ Rd. " "	.23
	14" Smooth "	.25
•	14" Rd. "	.16
•	Scriber	.04
•	Hand brush	.62
	File "	.40
•	Pinch bar	1.04
•	Scraper	.07
	Drifts	.06
	Tool box	.38
•	Locker key No. 93-58	.25
• • • •	Tool checks	1.25

No. 238- 3,4,5,69.

These tools being company property, I agree to be held responsible for care and safe keeping of same, or for value thereof.
I have received a copy of this record.
(Signed) Sam Jones

MACHINIST No. 238 SHOP M.V.
HELPER NAME
APPRENTICE Jones, Sam'l
GANG: 1 2 3 4 5
DATE Oct. 4. 04 CARD NO. 1213

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WORKMAN'S RECEIPT FORM FOR TOOL KIT, AS FILLED OUT.

The form—preferably on a card, 4 by 6 inches—is filled out in duplicate, original and duplicate being signed by the workman. He keeps one copy and the other is filed in the office. The mode is explained in fuller detail on page 799. The back of the card is shown on page 798.

Tool locker inspected:
Nov. 3 '04
Nov. 24 '04
Jan. 6 '05

No. M238 Tool locker No. M69 Key: W3-58

Shared by: No one

Clothes locker No. W43 Key: R 793

Shared by: B.B.B. Henry

Left service:

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BACK OF TOOL-KIT RECEIPT FORM.

The face of the form is shown on the preceding page. The entries here complete the current record of the kit in question, and complete the history when it is finally turned in on the workman's departure from the service.

In order that no opportunity may be given for the man to claim improper charging, it is well to have the list made out in carbon duplicate of which the man is given the original. This may be conveniently done in the following manner:—the cards are blocked in pads (gummed on one edge only, and that at the bottom) and are alternated with printed duplicates of thin paper. Cards and duplicates are serially numbered by machine, the card and its duplicate having of course the same number. Of these two the thin-paper sheet is the original. A carbon paper is slipped between it and the card, and an indelible pencil is used to write in the date, number of each kind of tool, names of extra tools, and the man's name at the top of the card where it will be legible and convenient for reference when filed in a case. The tools are ticked off by using a sharp-pointed instrument which will perforate the original thin slip, and yet not go through the duplicate card. The man signs his name in ink to both the original and the card. The original is given over to the man's possession, it being in such shape that he could not readily alter it without detection, and the card duplicate is placed on file in the main tool-room office. When a man leaves, the kit of tools he turns in is compared with this list, deduction being made for what is missing. So much for this record, which has many additional uses—for instance, as a running inventory of the value of equipment tied up in this way in small tools. On this slip also, six to ten tool checks are signed for, the number usually being fixed in a given department. These of course are for exchange at the tool-room window for special tools not included in the kit, such as taps, drills, gauges, etc. The checks should not be made as usual of sheet brass cut out and stamped in the shop, but should be made either of brass, or preferably aluminum, imprinted by a special die with the company's name, and numbered by means of an odd size and shape of steel figure which can not by any chance be duplicated by the shop men. In addition to this it would be well if all checks were numbered serially on the back. This can be cheaply done by machine if the checks are bought originally from some one of the large concerns making a specialty of them. Of course, a great many blanks (also serially numbered) are bought at the same time to provide for shop increase and checks that are lost. But the serial number makes possible an absolute record of every check given out, and in connection with a locked tool-room, and the signed slips for tool kits, not only renders the possibility of fraud remote, but also in a very substantial manner reduces the necessary annual investment in small tools. In a locomotive shop employing

1,200 men, where such a system was installed, over $600 per month was saved in money expended for small tools alone, above the expense characterizing the period when such records were not kept.

It is not sufficient to establish this system of individual tool kits with places for storage and to provide an efficient and definite means of checking from the tool-room. The system must be kept up in both cases, and means for doing so provided. While in theory it is excellent to have all tools returned to the tool-room at least once a week, in practice this will usually be found difficult, and the aim of this frequent tool-room supervision of tools will be attained if only the more important and scarcer tools are watched in this way, and the rest permitted to remain out until the man finds he needs to get other tools on the same checks. In order to avoid, however, the accumulation in men's lockers not only of tool-room tools, but of tools "borrowed" (by stealth) from fellow employees, or picked up about the shop, a regular inspection of tool lockers is essential. I have used for this purpose a young helper who would go about with his duplicate and master keys (record of the style and key number being kept on the same card with the list of the tool kit), after hours, nights and Sundays, checking up the tool kits assigned with the tool kits on hand, and also with the tools drawn from the tool-room. In this way any loss or breakage or "borrowing," or too long detention from the tool-room of tools often needed is detected, and the man is called to account the following morning by his foreman, at the instance of the tool-room foreman. Such a man, earning about $35 a month, was able to check over 800 men once a month, at the same time attending to the matter of providing tool kits for all new comers and checking up and furnishing clearances for all employees leaving the service.

I have tried numerous tool-checking methods; writing out a separate card each time a tool is drawn, the card being destroyed when the tool is returned; the book record, in which the man's name and the tools taken are noted on each occasion; the slate, a similar record wherein the notation is erased on the tool's return, or where each kind of tool is given a column, heading and lines being painted in white and the names of the men drawing each class of tools being entered in the respective places; the plain check system, by which a certain number of checks are alotted to each man on entering the shop employ, these checks being given to the tool-room in exchange for tools and placed on the shelf normally occupied by the tool; a modification of this system, similar to the modified slate record, wherein a large board at the tool-room window is arranged with

hooks or pegs corresponding to the different varieties and sizes of tools, the checks being hung on the hooks instead of being promiscuously scattered in the tool-room; and lastly, the double-check system, in which not only each man has a check, but also each tool, a check-board being provided at the tool window arranged according to the shop numbers of the men, for the accommodation of the checks belonging to the tools, the men's checks being hung on hooks placed by the location of the tools in their shelves or their pigeon holes. The last named system was found to be most exact when special care was needed to fix definitely the location of important tools, but was found too cumbersome in installation (though not in operation), for application to the general run of tools in a large tool-room, and was used, therefore, with success simply in the case of pneumatic tools, special taps and reamers, templets, gauges, and high-speed machine tools. The checks for the tools in question were made of metal pasted over with paper, on which was rubber-stamped the name of the tool, with indication of size and serial number, the tools in this case being stamped with such numbers on the soft shank. The face of the check was then gone over with shellac.

Most railroads keep a book or card record of repair costs to each locomotive. The reasons which justify this also justify a similar record in the case of machine tools. The card form of this record is the most convenient; and where it is kept by a general tool supervisor or foreman, or his clerk, it may conveniently include in its scope air motors and all the more expensive and special tools and jigs—say everything costing above $10. There will be one card for each machine tool, hand tool, or jig; first cost, and each item of repair or other charge, being entered on the card. Special tools, such as piston extractors, templets, and jigs, should be catalogued, and very definitely described, so that at any time in referring to this list it would be known just what standards were available. Sketches should be made in this catalogue so as to make the inscription entirely clear. For the smaller tools in the shop, even down to hand chisels, cards should also be kept, but for groups rather than for individual tools—a card for each size of drill, or reamer, or tap, a card for flat chisels, a card for each style of file. This tool record, it will be readily seen, in connection with the card record of men's tool kits, furnishes a running inventory, available at all times, of all tool equipment whatsoever; and the records kept in this manner, if summed up into classified statements (which may be very readily done), furnish a very valuable review of this account, and the guide to the more costly avenues

of tool expenditure, showing where the promise of savings would be largest with a given amount of attention. Not only this, but tools on requisition, those on the card inventory, and those accounted for by the tool-breakage clearances, should furnish reciprocal checks.

Many shop superintendents will be alarmed at the prospect of employing not one, but half a dozen to a dozen extra men for supervising and maintaining a thoroughly effective tool system; but it must be remembered that the wages of a few cheap men (and old men are often very careful in such matters) are a small item compared to the time and money saved to the mechanics. And such a system unquestionably means this saving of time, for it sees that each man is provided with the tools he most needs, with the least possible investment as a whole in hand tools by the company, and at the same time makes the interchange between tool-room tools and men so prompt that there is not the necessity of having to inform the man that certain tools are "out," or forcing him to spend half an hour wandering around finding a man who has what he wants. And men are encouraged to take some care of their own kits because of the company's efforts to prevent the habitual practice of stealing from one man by another.

I once worked in a shop where it was required to return special tools and gauges on the same day they were taken out, or as soon as the job was finished on that day. This system, while economical in the total number of tools required, was very costly—not only in the frequent running to and fro with tools, but also from the fact that because of the fewness of the tools, many and vexatious delays in getting work done were caused.

The problem of properly serving the men with tools cannot be solved by dogmatic rule, but must be worked out to fit the needs of each shop. In the case of a large railroad shop the following arrangement will usually be found satisfactory:—there will be one central tool-storage room, not necessarily (indeed, preferably otherwise) in connection with the manufacturing tool-room; from this central room all distribution of tool supplies will be made; then for each shop or department there is a smaller tool-room, set of shelves, or rack, containing the tools most used in that branch of the work, these sub-tool rooms being managed by the foreman himself (near his desk) or by a boy; then such tools as are needed from the main tool-room are called for by telephone (supposing each foreman to have an instrument at his desk, as should be the case in any well regulated and modern establishment of any size), this main tool-room having a

number of errand boys for the purpose of delivery. Where the shop is on more than one floor dumb-waiters may be used with great success. One may go too far, however, in attempting a system of this kind, such, for instance, having been the case where a tool-room in a large shop was equipped with an elaborate annunciator system. In the first place, the arrangement was continually out of order; the cranes jarred down most of the pointers every time they passed over the tool-room; the influence of the heavy electric power circuits played havoc in cross currents; and even when the system was in successful operation it was not economical, since the workman had to wait for a call boy to respond to his rings, then had to give his order, and finally —got the wrong tool.

Large wrenches and tools usually used on the erecting floor should be as rigorously cared for as the cutting tools furnished from the tool-room. Unless this is done (that is, unless they are checked out and returned to their proper places in a systematic manner) there will be constant difficulty and friction resulting from the mislaying of these tools. I have sometimes seen wrenches, etc., being carted off and dumped on the scrap pile by the sweepers, whose duty it was to clean up the shop Saturday night, and on Monday morning the men would be howling around and complaining that they could not get tools to do their work.

Among the lesser helps to efficient tool-room management may be mentioned not only the systematic grinding of twist drills, but also the maintenance of a plentiful stock of flat and cape chisels. Similarly with drift pins. Also the matter of promptly rehandling hammers should receive attention. Of course all broken tools should be exchangeable, after satisfactory explanation, for new. The tool-breakage clearance is referred to elsewhere.

Broadly speaking, the economies that may be brought about in the very first year, by an intelligent analysis of tool conditions, and energetic introduction of method, will be surprising—will seem incredible to those who have not studied actual cases closely. Spending money on *men*, and on the best tools, is one of the wisest forms of retrenchment.

THE WORK OF THE COMMISSION ON THE PANAMA CANAL.

By C. E. Grunsky,
Member of the Isthmian Canal Commission.

Mr. Grunsky's paper was originally prepared as an address; under the auspices of Admiral Walker, chairman of the Isthmian Canal Commission, it has been given exclusively to THE ENGINEERING MAGAZINE for publication. Its importance will be recognized, as it is a direct, authoritative statement of the work accomplished and the general policy and methods of the Commission in dealing with the construction of the canal. It gives to the professional and commercial public interested in the progress of the work the best idea obtainable at present of the actual conditions and the immediate prospects of the undertaking.—THE EDITORS.

PERHAPS no great work was ever undertaken by any nation which came so near receiving unanimous approval of all the people as the construction of a canal by the United States connecting the Atlantic and Pacific Oceans.

The oceans are separated by a strip of land which, as the crow flies, is at some points less than 40 miles wide. Ever since the discovery of the Pacific by Vasco Nunez de Balboa, in 1513, it has been the dream of adventurers, of scientists, of civil engineers, of emperors, and of nations, to see the union of the oceans at or near Panama an accomplished fact.

That conditions for the carrying out of the enterprise were not ideal is too well known to need comment, but in view of the many failures to accomplish any result beyond ascertaining what physical difficulties had been interposed by Nature, it is natural that the difficulties should ordinarily be considered much greater than they really are. The Isthmus has been made to appear as a land unlike any other part of the globe; something unreal, uncanny is made to pervade the very atmosphere, so that many who go there for business, or pleasure, are for weeks oppressed by a fear of they know not what and do not breathe easily until they get that famous view of "Colon" from the deck of a steamer bound for New York.

The stories of pestilence and death during the migration across the Isthmus while the great California gold excitement was at its height, during the building of the railroad, and again during the period of great activity under the old Panama Canal Company, are greatly exaggerated; but they have left their impression upon the public mind and it will take time to correct this impression.

The properties of the Panama Canal Company were taken over by the United States, on May 4, 1904. There were at that time about 600 laborers at work in the cut through the Continental Divide at Culebra, and the floating equipment, machinery out of use, buildings, and vast accumulation of material, were in charge of care takers.

The progress being made was not commensurate with the magnitude of the enterprise. The construction work appeared rather to be done to hold valid the concessions, than with an earnest effort at real execution. And this was quite natural. Had not the American people determined that they must have a canal? And whether at Panama or elsewhere, what need of increased effort? A location elsewhere than at Panama of an American canal would destroy the hope that a privately owned canal at Panama could be made a financial success. The French company had really no option; it had to accept what the United States was willing to give. The work it had done on the canal was only worth what the United States would pay for it, and an offer from the United States, it was easy to see, would not be affected by an increased rate of progress on the construction work. And so it was that no effort had been put forth for some years to improve methods of work or to increase the rate of progress. A thousand yards of excavation per day, less than 3,000,000 cubic yards in three years, was the output; and this was accomplished largely by pick and shovel methods. The Canal Company's work was under the management of a director-general, who was assisted by a meager staff of engineering and clerical employes.

The extensive hospital buildings at Ancon were in charge of a single physician, who, aided by a number of sisters of the Order of St. Vincent de Paul, cared for a few patients that were only inadequately provided for, and for a small number of orphans. All of the hospital buildings were sadly neglected, needing repair, and the grounds were overgrown with shrubs and weeds. A second Canal Company's hospital at Colon had practically gone out of use. A part of the main structure had succumbed to the force of a gale, and a few sick people, mainly members of the police force, were being cared for by the self-sacrificing sisters of the Order of St. Vincent de Paul to the best of their ability.

The members of the Commission, upon organizing in March, 1904, determined that an immediate examination on the ground was necessary in order that all members might be thoroughly familiar with conditions there prevailing, and to give those of its members

who had not before studied the canal problems an opportunity to acquaint themselves with these problems and with the physical and other obstacles that would have to be overcome in the canal construction work. This visit to the Isthmus preceded the taking over of the canal properties, but was fruitful in its results. The Commission found that it would be necessary, as soon as the United States entered into possession, to make additional special engineering studies and examinations of a number of problems of which the more important were the following:—

A special examination, with borings, at a dam site on the Chagres River at Gamboa, together with surveys covering certain indicated localities between the Chagres River and the Pacific Ocean to determine the feasibility of at least a partial diversion of Chagres floods to the Pacific slope.

An examination with borings at the Bohio dam site to supplement data heretofore collected by the Canal Company and by the former Canal Commission.

An examination with borings at Gatun to determine whether it would be feasible to erect across the valley of the Chagres, at that point on one of several possible locations, a dam sufficiently high to bring the summit level of the canal as far down stream as Gatun.

An examination with borings along an alternate canal location at Tiger Hill between Bohio and Gatun.

An examination, with surveys and borings, of portions of Limon Bay and adjacent country to serve in planning the Atlantic terminal of the canal, and the interior harbor which is there to be provided.

Also special examinations to determine the available source of water supply for the cities of Panama and Colon.

For this work of investigation; parties were organized as soon as the Commission was back in the United States. In charge of four assistant engineers the studies were commenced within a few weeks after taking possession of the canal properties.

Meanwhile the Commission had been considering the selection of an engineer who could be placed upon the Isthmus as the executive officer of the Commission in charge of the canal construction work. This choice fell, as is well known, upon a member and past president of the American Society of Civil Engineers, Mr. J. F. Wallace, whose large experience in railroad work and in the arrangement and direction of transportation facilities, and whose great executive ability, seemed to indicate him as specially qualified for the position. No change was made in the Commission's plans when he entered

upon his duties in June. The Commission has continued the investigations above indicated, placing them under his direction; and hopes that within a few months the data will be at hand that will enable the Commission to cope with and to reach a conclusion on the main question as to the type of the canal.

The question is often asked:—"Has not this matter of the elevation of the summit section of the Canal been already settled by the last Isthmian Canal Commission, and by the action of Congress in appropriating $145,000,000 for the purpose of the work?" It should be remembered in this connection, that the last Commission carried its investigations far enough to justify its conclusion that a canal could be built; that in the light of the available data, the project that was tentatively adopted and described appeared the best; and that on the basis of assumed unit prices, its estimated cost would be as reported. A comparison with other canal routes was thus made possible, but the question was not settled whether or not the best project was this particular one with the canal summit level at 85 feet above the sea. The present Commission would not be performing its duty fully if it did not place itself in possession of the information necessary to determine whether the summit section of the canal should not be at 60 feet instead of over 80; and if this alternative is to be analyzed, then why not know whether, everything considered, the canal should not have a still lower summit section, or possibly be constructed at sea level? In reaching a conclusion on these points the question of feasibility of carrying out the work is not the only one of moment; the cost of the work must be taken into account, and cost of operation and maintenance after construction; the time required to complete the canal; the advantages and disadvantages of each type to shipping interests; and also the degree of risk involved in the maintenance of the works. That the element of risk is not all in favor of the canal which is free from locks will at once be realized by every engineer who visits the points of maximum cut, noting the shattered and unstable formation, where landslides, if occuring, might seriously and for long periods of time impede traffic, and where the magnitude and seriousness of such an obstruction, and consequent interruption of traffic, should it ever occur, must be assumed to grow with the depth of the cut.

Sufficient information to justify a final conclusion as to type of canal was not collected by the old or the new Panama Canal Companies, nor was it collected by the last Isthmian Canal Commission. It was not required by the former, owing, in the main, to the fact that

theirs very soon became a problem to construct a canal as a concessionary within a fixed time limit, and of such a character, of such a size, and at such a cost, that it would be a paying investment. Theirs became a plan for a canal with a bottom width of about 100 feet and with a summit level at about 65 feet, to pass vessels with a draft of about 29 feet. When these canal dimensions are compared with those suggested by the last Commission, and which also remain subject to modification (being a bottom width of 150 feet and at least 35 feet of water—and there is now no other time limit nor limit of cost than such as can be justified by considering all circumstances) it must at once be apparent that the Commission is dealing with a new problem and cannot enter upon large contract work until the canal to be built shall have been designed.

The investigations of the last Commission, as already stated, were carried far enough on the line of the Panama Canal to serve a specific purpose. They were not, as a matter of course, intended to furnish the information required in making final plans of the work. They are good as far as they go, and they are being supplemented by the work that has now been in progress, as indicated, for seven months.

The borings which the Commission has made at Gamboa indicate that there will be no difficulty in securing a good foundation for a dam across Chagres River at that point. As this fact had been indicated by the examinations made by the French engineers, no other result was expected. It is quite probable that the Commission will see its way clear to the erection of an earth dam of huge dimensions at this point. There is no reason why this locality should not be made one of the spoil banks for the material requiring transportation on cars. Assuming that this dam will be built, instead of the one which has been considered as an alternative at Alhajuela, and that its crest will be carried to an elevation of about 200 feet above sea level, there would be created above it a lake with a surface extent of about 30 square miles, the rise and fall of which would prove a great equalizer of the flow of Chagres River, and—making the diversion of a portion of this river's flood flow to the Pacific slope feasible—this would go far toward so reducing the amount of water to be handled in the canal that its flow would not seriously impede the passage of vessels in a sea-level canal.

It should be stated that this matter of a diversion of Chagres River to the Pacific Ocean was also studied by the French engineers, and that the new information obtained by the Commission relates

mainly to the complete exploration of a dam site to determine position of bed rock, and to the measurement of the length of a tunnel, at an elevation of about 175 feet above the sea, from the valley of the Chagres to a stream flowing into the Pacific Ocean. This tunnel length in the location examined would be between seven and eight miles.

As soon as a definite program could be agreed upon, purchase was made of 14 modern steam shovels, some of which are already at work, and of which the last will reach the Isthmus within six months. These are being put to work as rapidly as the ground can be prepared to receive them, each one adding about 1,000 cubic yards per day to the output. This excavating plant will be supplemented by car unloaders and bank spreaders, which have already been purchased, and, in fact, by every labor-saving device that can be employed to advantage, it being self-evident that where conditions are not favorable for labor, this should be replaced by machinery to the maximum extent possible. The use of machinery and labor-saving devices will not only be of direct benefit in expediting the work, but of indirect benefit as well, by reducing the number of employes and consequently the sickness, loss of life, and attendant cost.

Careful records will be preserved to determine the unit cost of excavation, and of the delivery of material to the spoil banks. The excavation work will be continued with a steadily increasing force during the time that plans are being made on the basis of which contracts can later be awarded.

The Commission will thus be in possession of facts, before awarding large contracts, relating to the efficiency of appliances and of labor operating under the local conditions, that will be of great service to contractors in submitting proposals; and that will also be a valuable guide in determining whether proposals are reasonable or not.

The Commission is at present engaged upon the preparation of specifications for a dredge of modern design, with which harbor dredging and canal work near Colon are to be undertaken.

It is self evident that any modern plant, used by the United States in the canal construction work preceding the letting out of the work by contract, can be turned over to contractors in case that contracts are awarded. The United States would, in such event, receive the full benefit of the value of any machinery turned over. Meanwhile, all of the work done with any plant now purchased is useful work, and brings nearer the date of the completion of the canal.

The Commission's work has extended into other fields besides the collection of engineering data and a study of engineering problems and construction work. It has organized a sanitary department whose main duty is, and the Commission hopes will ever continue to be, to prevent the spread of disease, to prevent epidemics of contagious and infectious diseases, and to make and maintain the Isthmus a healthful region. This work is carried on with a thoroughly organized staff, including a board of health, sanitary officers at Panama and Colon—where the United States may prescribe health regulations and, local authorities failing, enforce the same; a sanitary service for the Canal Zone, maritime quarantine service at Colon and Panama and the Canal ports, besides the necessary hospital service.

The employes of the Commission are given free medical treatment and care at hospitals, of which the main one at Ancon is in full operation and a second one at Colon is being repaired and enlarged. Besides these hospitals there are emergency hospitals and dispensaries along the line of the canal.

The health-department organization is such throughout that it is capable of expansion as occasion may arise. Even as at present organized the expenditures by the health department, including the work of sanitation, such as draining or oiling ponds, covering water containers, abating nuisances, removing waste and night soil, will probably pass the $1,000,000 mark before the close of the current fiscal year and will thereafter be in the neighborhood of $800,000 per year. This large expenditure is justified because by such measures as are being taken the Isthmus will unquestionably be made and kept as healthful as any country similarly situated, having similar climatic conditions.

In the matter of making purchases the Commission is not as favorably circumstanced as would be a board of directors of a large corporation, which the Commission somewhat resembles. Its work, being a national enterprise, makes it imperative that so far as practicable every section of the commonwealth, manufacturers and merchants throughout the land, should be given equal opportunities to furnish machinery, materials, and supplies for the use of the Commission. This means competitive bidding, so far as competitive bidding can be made practicable, and the award to lowest and best bidders. The Commission recognizes this fact and has acted accordingly. It has adhered to this principle, even in many cases when the difficulties of ascertaining the merits of the individual proposals

were great and when this method of purchase was the cause of much annoying delay. It has resulted, however, in the distribution of the purchases thus far made to widely scattered sections of the United States.

The members of the Commission are directors of the Panama Railroad Company which, in addition to the trans-isthmian railroad, operates a line of steamers sailing weekly from New York to Colon. The railroad company owns three steamers and charters others as required. Sixty-nine seventieths of the stock of the Panama Railroad Company is now the property of the United States, having been acquired as part of the property transferred by the Panama Canal Company.

The territory over which the jurisdiction of the United States has been extended on the Isthmus, though small, having an area of only about 450 square miles, requires the same attention in the matter of suitable government as though it were of much larger extent. Coupled with this is the fact that the Canal Zone is not a productive area, and that any system of taxation that would make the government of the zone self-supporting would be burdensome. The Canal Zone government will probably never be entirely supported by local revenues. In organizing a government of the zone, the Commission has enacted laws establishing a judiciary, providing for municipalities and their government, prohibiting lotteries and gambling, establishing an executive department; besides enacting a penal code and a code of criminal procedure. The Commission has also given its sanitary rules and regulations the force of law, and has prescribed the sanitary regulations which are to be put into force by the Republic of Panama and Colon.

During the progress of the canal work practically the entire population of the Canal Zone will, directly or indirectly, be dependent upon the canal work for its support. The use and rental or possible sale of public lands will be regulated with proper regard for canal requirements; all business affairs and enterprises of every character must be so regulated as to be properly co-ordinated to the operations of canal construction.

In short, the Canal Zone Government, the canal construction work, the sanitation work, and the operation of the railroad which parallels the canal, which must be kept in uninterrupted service for the transit of merchandise over the Isthmus and which is an invaluable aid to the canal construction work, must all be under the direction and control of the same managing body.

The Commission transacts its business at stated and special meetings which are generally held either at Washington or on the Isthmus; rarely elsewhere. During the period of organization and the study of the canal projects, its work, as a Commission, has been mainly at Washington, its affairs on the Isthmus being directed through its executive officers there stationed. Its duties have in a measure been subdivided, questions of importance being referred to its standing committees of which there are six:—the executive committee; the committee on engineering; the committee on finance; the committee on legislation; the committee on sanitation; and the committee on engineering plans, which last is made up of the engineer members of the Commission, the chairman being ex-officio a member of all committees. The governor of the Canal Zone is a member of each committee when meetings are held on the Isthmus.

It is proposed so far as practicable to have the committees follow each other to the Isthmus, thereby keeping three members of the Commission in close touch with its executive officers in charge of construction, sanitation, and the government of the Canal Zone. No one can visit the Canal Zone at the present time without being impressed with the orderly conduct of the work in the several departments created by the Commission.

The government of the Canal Zone, with an executive branch, a judiciary, a department for the collection of revenues, a postoffice, a police force, and the like, has one of the members of the Commission at its head. Nominally the health department has been made a part of the executive branch of the Canal Zone government, although its duties are by no means confined to the sanitation of the Canal Zone, and its affairs need and receive the supervision of the Commission.

The material and supplies department has been put in charge of the machinery, material, and supplies that will be required and handled on the Isthmus. A special board of appraisers is listing and appraising the value of all machinery and material turned over by the Canal Company, which, to the greatest extent possible, will be made use of in the canal construction work. This property stood upon the books of the Canal Company at nearly $30,000,000; its actual value, however, though considerable, and more than was at first expected, is only a small fraction of this amount.

The engineering department has charge of all construction work, and of engineering investigations.

It may be of interest to note that the abundance of clay and other light material to be excavated in making the great cut at Culebra

prompted the Commission to have a special examination made by an expert in hydraulic mining methods, and that his conclusions indicate a possible alternative method of doing a large part of the required work at this point.

The construction work of the French Company has been continued without interruption; but American methods of doing work and American machinery, as already stated, are being introduced as rapidly as possible. Laborers in large numbers have not been sent to the Isthmus because the time for any considerable increase of force has not come. Not only is the question of type of canal to be settled before an adequate distribution of a large working force can be made, but time is required to prepare the Isthmus for a large influx of canal employes. Neither material nor artisans have been so quickly available that suitable quarters could be provided as rapidly as the Commission desired. The Commission is not yet in position to furnish quarters to all of its employes now on the Isthmus, and some additional time must elapse before this can be done. It takes time to select sites for buildings, to construct water works and sewer systems, and to effect land purchases and purchases of material, and to erect structures. These matters are all receiving attention, but in the meanwhile the staff of employes can not be indefinitely increased. It should be added that the Commission has constantly discouraged the taking of families to the Isthmus in advance of the completion of the preparations for its employes, on which, at present, the Commission is most active.

There are now on the Isthmus in the employ of the Canal Commission and in the employ of the Canal Zone government, about 3,600 people. The sickness among these employes has averaged about 3 per cent.

Neither Panama nor Colon is an inviting place for residence. Neither of these cities has a water supply; neither of them has a sewerage system. Under the treaty with the Republic of Panama the United States is authorized to construct water works and sewerage systems for these cities, recovering their cost in a long series of years. The Commission took immediate action in these matters, planned water works for Panama and a sewer system; has bought the material for the same and is pushing the work of construction as rapidly as circumstances permit.

The combined cost of water works and sewers for Panama will be in the neighborhood of $750,000. Similar work for Colon is not as far advanced, there being some special problems involved in that

city. It may even be found desirable to raise the ground surface of Manzanillo Island, on which Colon is located, before constructing the sewer system.

When a high dam has been constructed across Chagres River, either at Gamboa or at Alhajuela, the vast lake thereby created will afford an excellent source of water for domestic use and will, without doubt, be the ultimate source of supply for the entire Canal Zone and the two cities, Panama and Colon.

It may also be stated, in passing, that either of the dams mentioned, while furnishing water for canal purposes, will yield abundant water power which, by electrical transmission, will become available along the entire length of the canal. It is easy to foresee that the power and electricity thus generated will add to the comforts and conveniences of the inhabitants of the zone and will become valuable aids to the canal construction, and subsequently in the operation of the canal as well as in the operation of the railroad.

It should be added that the affairs of the Commission thus briefly outlined must necessarily involve the receiving and disbursing of large sums of money. Suitable provision has been made for a proper classification of expenditures, and for such supervision, control, and inspection that misappropriation or embezzlement of public moneys cannot escape detection, and so far as check systems and supervision can accomplish this, will be prevented.

The total disbursements of the Commission to the close of the year 1904 have been $1,060,000. The purchases to date, including some not yet delivered and paid for, aggregate $888,700.

The progress made to date has been reasonable, but neither it nor the work of the next few years can or should be measured merely by cubic yards of excavation.

Whether Congress in its wisdom permits the great work to be carried on under the management and direction and according to canal plans designed and recommended by the present Commission, or whether some other plan of management, control, and design be adopted, the American people may rest assured that American directness of methods, American energy, American engineering skill and resourcefulness, will make the canal work just as certain of accomplishment as though the Isthmus were located in our temperate climate, close at hand, instead of at a distance in the tropics. The work will be done; it must and will be well and honestly done.

EDITORIAL COMMENT

TO many earnest friends it may be a disappointment that in the article upon the Panama Canal with which General Abbot leads this issue, he does not favor the sea-level project; but the manifest fact will appear to them that the point is to be decided not by the sentiment or the *seeming* conditions embodied in a name, but by the *actual* conditions which would exist, and by the clear logic of fact. General Abbot's article is a brief and most succinct statement of these conditions as they are known to him, and the conclusion to which they lead. This conclusion, it is hardly necessary to repeat, is that the sea-level canal would not be the safest nor the most attractive to navigation, chiefly because the treatment of the problem of the Chagres which it necessitates is far from satisfactory. That which is embodied in the lock and summit-level plan, on the other hand, is absolutely complete and transforms the river from a menace into an aid. And it must be kept plainly in view, in studying the question, that in the navigation of narrow waterways, deep-sea navigators attach vastly more importance to maximum safety than to minimum time.

In construction also, as well as in operation and maintenance, the lurking menace of the unforeseeable and unpreventable seems to hang about the sea-level scheme. This is clearly suggested by Mr. Grunsky in his comment upon the increased difficulties of the Culebra cut if carried to the vast dimensions demanded by a sea-level canal. It is touched upon also by General Abbot in his reference to the river-diversion tunnel which forms part of the scheme, and the point seems worthy of strong emphasis. A tunnel of the length and cross section demanded by the conditions of this case would be a serious proposition even in the most favorable formation—and the formation on the Isthmus is distinctly the contrary of favorable. It is folded, faulted, shattered—eruptive, and even now not wholly free from earthquake disturbance. In a sense, any engineering undertaking is possible; but concerning the proposal to bore such a hole as this through such materials as are likely to be encountered, one might well quote the dictum of a high authority concerning the discarded ship tunnel of another route—that "the possible contingencies of an undertaking of this kind might well prove such as to tax the abilities of the most able commission, backed by a rich and generous Government."

* * *

WHILE we sincerely respect the Commission's determination to consider every type of canal, from the sea-level to the highest summit proposed, we are inclined to attach more weight and finality to the conclusions of preceding commissions than is intimated in Mr. Grunsky's paper. The late Mr. George S. Morison expressed to us the most confident conviction that the studies of the commission of which he was a member were ample to decide not only the relative merits of the Panama project, but the absolute type of canal to be built. It is well known that his

judgment approved a summit level at a normal elevation of 85 feet, making a single large lake, extending through the Culebra cut and thus greatly reducing the necessary excavation there. As he put it in a conversation very shortly before his death: "Your two big problems are the Culebra cut and the regulation of the Chagres. They must be treated together. By raising the crest of the Bohio dam, you reduce by so much your maximum cut, and at the same time make the summit lake high enough and large enough to receive and control the floods of the river. The one problem disappears and the other is minimized." General Abbot, whose familiarity with the hydraulic data of the problem is unrivalled, most earnestly advocates a summit level of only 66 feet, with a second dam above this at Alhajuela, to control and regulate the volume admitted to "Lake Bohio," urging that this plan presents important advantages in construction and secures more absolute certainty of the maintenance of water supply and of unembarrassed navigation under all possible conditions. We believe that the present Commission might justifiably, and even commendably, have limited its consideration to these two main plans and certain variants.

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MR. HASKELL'S article on American railway accidents, which appeared in our issue for December has attracted widespread notice, which reaches us mingled with an outcry from those who feel themselves arraigned, and from their would-be apologists. Perhaps the most remarkable comment is that made by the New York *Tribune*. If engineers are not allowed to disregard signals, it says, the trains will be delayed. To come down to the level of this "criticism," we may point out that when signals *are* disregarded, the trains are, not infrequently, still more seriously "delayed." There is, however, in all well informed quarters a very general recognition of the correctness of Mr. Haskell's analysis, and in many a distinctly apparent relief that someone has been found with the independence and the courage to speak plainly. Even the railway periodicals, while protesting against the admission that anyone who is not an active railroad official could possibly have any useful ideas on railroad affairs, yet reluctantly grant that there is "something" in these views.

Next to that of the *Tribune*, the widest miss in getting at the point is made by some of the labor organs, which grow very angry and vituperative at the supposed disposition to throw all the blame on the employee. It should be clear enough to anyone capable of reading and understanding good English that the conditions charged by Mr. Haskell point most accusingly to "the man higher up." By practically punishing strict obedience to rules when it entails delay in train movement, and by ignoring disobedience to the same rules so long as no actual accident follows, the "man higher up" forces the engineman to take the chances which too often result in disaster—and then retires behind the screen of the rules he made to be broken, and leaves the unfortunate employee to bear the responsibility of having broken them. It is he, and not Mr. Haskell, who puts the blame upon the engine and train crews.

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WE have received from the secretary of the American Society for Testing Materials a communication explaining the present methods of conducting the work of the organization, from which we make some interesting abstracts.

The International Association for Testing Materials, with which the American society is affiliated, has for its objects: "the development and unification of standard methods of testing; the investigation of the tech-

nically important properties of the materials of construction and other materials of technical importance, and also the perfecting of apparatus used for this purpose."

At the last congress of the International Association, held in 1901, at Budapest, the following resolutions were introduced, and adopted:

I. On "the creation of an International Committee on the testing of cast iron and the establishment of standard methods of testing and specifications." Referred to the council for more careful consideration.

II. "Committee 1 is directed to submit to the next congress a report on the possibility of establishing standard international specifications for the quality of materials, basing its investigations on its tabulation of specifications in the various countries, and in case the report be favorable, to present a definite proposition with reference to the same."

III. "In case this motion be approved by the congress, it shall be extended to cement, and that part of the work be assigned to Committee 2."

At the tenth meeting of the council, held in Vienna, March 1–2, 1902, the following action was taken on Resolution I, above:

"That the question of uniform methods of testing be separated from that of uniform specifications for delivery; that the first part be assigned to a new committee and the second to Committee 1."

In the judgment of the executive committee of the American society, the subjects of specifications and methods of testing are indissolubly connected, except in so far as testing for strictly scientific purposes is concerned. Interest in the latter field being confined to a comparatively limited number of individuals in this country, a beginning was naturally made with such work as appealed to a wide circle of American engineers and to the consumers and manufacturers of the materials of construction. Care was taken, however, not to allow subjects of commercial interest to overshadow those more strictly scientific.

It thus appears that the American society has decided to consider the questions included in methods of testing in connection with the specifications for the materials under consideration, and in the specifications already prepared directions for testing are found. The American society has also appointed special committees on the following subjects:

1. Standard Methods of Testing.
2. Uniform Speed in Commercial Testing.
3. On Standard Tests for Sewer Pipe.
4. On Standard Tests for Lubricants.
5. On Reinforced Concrete.

Under these circumstances we may expect reports upon the subjects referred to these committees and we shall await their appearance with interest. We understand that the first of these committees is expected to make an early report on the standard forms of test pieces adopted by the British Engineering Standards Committee, while the committee on reinforced concrete is co-operating with like committees of other leading societies, and a joint committee on this subject is now actively at work.

* * *

If the amount of matter, written, printed, and spoken, about the steam turbine were to be taken as a measure of its preponderance in the department of prime movers, it might also be assumed that the days of the reciprocating steam engine were already past, and that the machine which was our main reliance yesterday had today become a candidate for the halls of the engineering museum. Nevertheless the many and great establishments which are devoted to the design and construction of reciprocating engines continue to manufacture their products,

while the comparatively limited number of shops devoted to the construction of steam turbines is not being very rapidly enlarged. The steam turbine is all right, and the claims which are made for it by its most enthusiastic advocates are based upon sound mechanical and technical principles, but the industry of manufacturing steam engines need by no means be stampeded on that account.

Apart from the direct considerations which may be advanced in favor of the turbine over the piston engine, there are several points to be taken into account—points which, while now secondary, may ultimately become of controlling importance in connection with the impending transformation in the design and use of motive-power machines. As has been well shown by Professor Denton, in his thoughtful paper presented before the International Congress of Arts and Sciences, the reciprocating steam engine appears to have reached very nearly the practical limit of steam economy which may be expected from that type of construction, so that the turbine must begin where the reciprocating engine leaves off. It is not expected, however, that the steam turbine will greatly surpass the piston engine in steam economy, and its greatest advantages appear in its freedom from the inertia effects of reciprocating motion, and in its direct application to electric generators, screw propellers, centrifugal pumps, and similar machinery.

As a matter of fact it appears as if the turbine had arrived just in time to form a sort of intermediate machine between the reciprocating steam engine and the improved internal-combustion engine, and that while many steam turbines will doubtless be constructed and used, the reciprocating piston engine will be found working along by its side until both are outstripped by the machine which uses the direct products of combustion for the generation of motive power without the intervention of the vapor of water.

* * *

AMONG the rivals to the steam engine and the steam turbine, the gas turbine offers most enticing attractions, and the eagerness with which any authentic information concerning actual experiments in this line is sought is evidence of the extent to which the subject is being studied. Theoretically the gas turbine should be an operative machine from which an efficiency nearly, if not quite, equal to that of the four-cycle reciprocating internal-combustion motor may be obtained. Practically there are many difficulties in the way, difficulties which it may require the utmost ingenuity of designer and constructor to overcome.

Thus the conditions of maximum efficiency in such a machine involve rotative speeds at which the centrifugal stresses become greater than the resistance of any available material of construction, while at the same time the working temperatures are indicated to be those at which the resistance of almost any material would be gone anyhow. The efficiency of the gas turbine itself becomes also involved with that of the efficiency of some appropriate form of air compressor, and the rotary air compressor available for such purpose involves nearly if not quite as many constructive difficulties as those of the gas turbine itself. Nevertheless we believe that the gas turbine will ultimately be made, and that it, or something like it, will be found superior to any steam engine which can be constructed. Meantime, the builders of reciprocating engines and of steam turbines will continue to produce their respective machines without fear of losing their business over night, and the advent of the gas turbine will be heralded sufficiently far in advance to permit them to give themselves ample protection.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

HYDRAULIC POWER IN GREAT BRITAIN.

THE POSSIBILITIES OF COMPETITION OF HYDRAULIC STATIONS WITH STEAM POWER IN THE UNITED KINGDOM.

E. Ristori—Engineering.

DURING the past ten or fifteen years there has been a great activity in the development of hydraulic power, this being doubtless stimulated by the opportunity of electrical transmission and application. In this development Italy has under utilisation about 300,000 horse power, and France 500,000 horse power, while in Great Britain it is estimated that there is not more than 10,000 horse power of hydraulic energy now developed. In a paper in a recent issue of *Engineering*, Mr. E. Ristori discusses the possibility of the development of a much greater quantity of water power in the United Kingdom, and shows that it may be able to compete very effectively with steam power.

The meager development of British water power Mr. Ristori attributes to two causes: the natural reluctance of the people to take up with new things, and the prevailing idea that there exists no water power capable of successful development, especially in competition with steam in a land where coal is cheap.

"The most natural sources of water-power are waterfalls, such as the falls of the Rhine, those of Shawinigan, Niagara, and many others. But these are by no means the only instances where water-power may be developed, as wherever there is a combination of a large watershed near to such geographical formation of the ground affording a suitable site for a reservoir, and a considerable difference of level within a short distance of the storage, water-power may be developed advantageously. On the West Coast of Scotland, in Wales, and in the West of Ireland there are a great many places where these conditions can be found, and where water-power can be developed just as cheaply as in many places abroad.

"The climatic conditions in these districts are very favorable to water-power, as, first of all, the rainfall is much larger and more uniform than in most places. This means that the watershed required for a certain amount of power is smaller in proportion, and also that the capacity of the reservoir need not be so large. For instance, it is quite safe to provide storage for only 100 days in these places, whereas in other countries it would be necessary to provide for 150 or even 200 days to avoid any risks in case of long droughts.

"Another advantage in favor of these districts is the uniformity of the climate, as either great heat or intense cold are seldom experienced. The difference between the maximum and minimum yearly temperatures is comparatively small, which facilitates greatly the construction of pipes and transmission lines, as the expansion and contraction of the metals is limited. The winters are also much milder, especially in the West, and, therefore, there is no danger to be feared on account of hard frost.

"Another great advantage is that in the west of the British Isles there is not likely to be lack of water during the winter months, which is generally the case in such countries as Switzerland, north of Italy or Canada. in fact, in all countries where snow is depended on for storage, and where, ow-

ing to the very cold weather in winter, the snow is held up and the rivers run nearly dry."

It being seen that the geographical and climatic conditions are as favourable in Great Britain as in other countries, but it remains to be shown that hydraulic power can compete with steam, under existing conditions. In general the opinion is that the cheapness of coal in the United Kingdom, and the efficiency of modern engines, permits little, if any, advantage in the use of water power.

"This statement is based upon the misapprehension that coal is the largest item in the cost of power produced by steam or gas. This is true in such localities where coal reaches very high prices, owing to distances from the coal-fields and difficulties of transport. Generally, however, this is not the case, and, in fact, the cost of fuel is only one of the many items, and proportionately not a large one, that go to make up the total actual cost of generating electric energy.

"It must be borne in mind that, in order to work a steam plant to the best advantage, a number of auxiliary appliances are required, such as coal-handling plant, mechanical sotkers, economisers, condensing plant, besides the necessary feeding-pumps, and other machinery. All these items involve a large capital expenditure, with the resulting heavy maintenance and depreciation. Also, it is well to remember that a steam-power factory involves much ground and a large building to house engines, boilers, and all other appliances, and also necessitates chimneys, and other structures.

"In the case of water-power installations the station buildings are much smaller, as only space for turbines is required. The electric portion of the plant, and the space taken by it, must be exactly the same whatever may be the source of power; therefore a water-power generating station must be smaller and less expensive than one where steam is the motive power.

"As regards the capital cost of the installations, in either case it is interesting to compare the figures, analysing at the same time the methods by which the expenditure is incurred. The electrical portion of the plant in any generating station is independent of the motive power used, whether steam or water, but has to be designed suitable for the purpose for which the station is required."

Mr. Ristori computes the capital and operative costs of hydraulic power plants with those operated by steam, under the conditions existing in Great Britain and shows that the installation costs of a water-power plant should not exceed £20 per horse power, and that in many places this may be reduced to £10 to £15 per horse power. The permanent character of the works renders it safe to estimate the depreciation charges at not more than 1 per cent. per annum, while interest is taken at 5 per cent. on the investment. In the case of steam power, the installation costs range from £15 to £20 per horse power, while the nature of the plant requires a depreciation charge of not less than 5 per cent. per year, the capital again bearing 5 per cent. interest. Under these conditions the fixed annual charges work out 12s. to 24s. for the water power, as against 30s. to 40s. for steam, the running expenses to be added in both cases. Mr. Ristori considers a number of cases at different load factors, and comes to the conclusion that the annual cost of a steam horse power in Great Britain will be, in round numbers about £4, while water power under similar conditions will not exceed £2 per horse power per year.

It is undoubtedly true that the public opinion about water power is influenced by the conspicuous examples of great power stations at the well known waterfalls which have been provided by Nature, but it is also true, as Mr. Ristori states, that large amounts of hydraulic power may be obtained under less imposing conditions. In the United States some of the largest hydro-electric stations have been developed from sources at one time inconspicuous. Thus the water power at Massena, in New York, has been developed simply by cutting a canal across from the St. Lawrence river to the Grasse river, utilising the difference in level between the two streams at a point where they are but a few miles apart. In the Western States it is a common plan to obtain water power by diverting a portion of a stream and carrying the flow along in a ditch with but a small slope until the fall in the main stream has given sufficient difference in level to provide for the necessary power.

There is no doubt that similar methods would enable much valuable water power to be developed in Great Britain with but moderate installation cost where at present nothing is apparent.

The influence of the cost of fuel upon the cost of steam power is also a matter concerning which there is often a misconception.

As a matter of fact the fuel element in the cost of steam power is but one of a number of items in the steam-power cost account, and in the United States, with coal costing from $3.00 to $5.00 per ton, it has been found that in a large power plant the fuel cost ranges from 40 to 50 per cent. of the total, and any variation in fuel consumption therefore affects the result in about those proportions.

THE DEVELOPMENT OF THE ELECTRIC LOCOMOTIVE.

A COMPARISON BETWEEN THE STEAM AND THE ELECTRIC LOCOMOTIVE FOR MAIN-LINE RAILWAY SERVICE.

Howard S. Knowlton—American Electrician.

WE have referred already in these columns to the highly successful trials which have been made with the first of the powerful electric locomotives for the New York Central Railroad, and now we have a paper in the *American Electrician* by Mr. Howard S. Knowlton discussing the influence which the development of these machines may have upon rapid transit on main and local railways.

The electric locomotive is by no means new, but its work has until recently been limited to special service in localities where steam machinery is objectionable. In the United States the principal application has been in the Belt Line Tunnel at Baltimore, and in Europe the operation of the extension of the Orleans Railway in Paris, discussed elsewhere in this issue, forms the most notable example. A few years ago a fatal and most costly collision in the Park Avenue tunnel in New York City called attention to the danger of the continuance of steam locomotives for this service, and the result has been the most powerful impetus which has yet been given to the question of electric traction on main lines.

The new locomotives for the New York Central Railroad have already been described in these columns, but Mr. Knowlton makes some interesting comparisons between them and steam locomotives in general and with a typical locomotive in certain details.

"Small resemblance exists between these electric locomotives and their steam prototypes. The frame is of cast steel; the wheels and trucks are of substantial design also; but the absence of the usual enormous boiler, cylinders, connecting rods, stack and tender results in an affair which looks more like an iron box mounted on wheels than anything else. The cab is built in the middle of the locomotive, and the machine will run equally well forward or backward without turning around. Of course, the steam locomotive will do the same thing, but the electrical horse has no front and rear ends, each end being front or rear according to the direction which happens to be taken. Practically none of the mechanism is visible—a marked contrast to the old-time locomotive. The new machines are equipped with electrically driven air compressors for operating the brakes and whistles, a bell and sanding device, and an electric headlight at each end. The cabs will be heated by electricity, and the motive power is furnished by four 550-h. p. motors capable of being overworked up to a total of 2800 horse-power. This means that each machine is half as large again as the largest steam passenger locomotive in existence, as far as power is concerned. They are designed to pull light trains at speeds as high as 75 miles per hour, and when it is desired to make fast time with the heaviest limited Pullman trains, two electric locomotives can easily be coupled together and operated by a single driver. This is made possible by the multiple unit control system, which is very similar to that used on the Boston and Manhattan elevated trains.

"It is interesting to compare the electric machines with a typical suburban steam passenger locomotive, such as is used by the Philadelphia & Reading Railroad. The electric locomotive weighs 95 tons, against

the steam's 100; the length of track occupied by its wheels is but 27 feet, against its rival's 30 feet 9 inches; its driving wheels are but 44 inches in diameter, against the Reading engine's 61⅝ inches, while the steam machine has a 'tractive effort' or horizontal pulling force of but 18,000 pounds, compared with 22,800 pounds in the electric locomotive. Even the latter can be considerably exceeded for short intervals without injuring the motors. Comparing the New York Central machine with one of the largest passenger locomotives in the world—the 175-ton engine of the Santa Fé system—the steam machine requires 62 feet 10½ inches of track to accommodate its wheels, or more than double the length taken up by the electric locomotive, while with a weight of 74 tons upon its 69-inch driving wheels it can develop but 22,200 pounds horizontal pull. In other words, the Reading engine, especially designed for rapid acceleration, has a pulling force of but 180 pounds for each ton of its weight; the Santa Fé machine has 127 pounds tractive effort per ton of its bulk; while the New York Central outfit will easily show 240 pounds tractive force per ton of its weight. A great advantage of the electric locomotive in this connection is the uniform pull exerted throughout each revolution of each driving wheel, made possible by the rotary motion of the motors, as contrasted with the reciprocating mechanism course, that the electric trains can attain of the steam engine. This means, of full speed in a much shorter time than trains propelled by steam."

As we have already noted, the introduction of electric traction on main lines has not been welcomed by railway engineers and managers. On the contrary, it has been forced upon them by reason of the external pressure to abate nuisances or prevent disasters. Its general use cannot be expected until it has been demonstrated that there is a material commercial advantage, and that electricity, plus stationary power houses, is cheaper than the traveling power houses we call locomotives. Apart from the question of actual cheapness there may also be considered the approach of the heaviest modern freight locomotives to the limit of operative capacity. It has already been realized that the firing of the modern heavy merchandise engine is becoming too severe a task for one fireman. The use of two firemen has been found unsatisfactory, and the perfect mechanical stoker for the locomotive has not yet been produced. Still the demand comes for greater boiler power, involving greater coal burning capacity, and it may be that the close approach to the limit of capacity in this direction may compel the removal of the power house from the wheels and cause it to be placed where its size does not affect the operation. Still it must not be understood that all difficulties will be removed by the removal of the motive power from the traveling machine. Some evils will disappear, but others will take their places.

"One must not imagine that the elimination of many of the inconveniences of steam locomotion means that the adoption of electric motive power has no drawbacks. Breakdowns in equipment cannot always be prevented, even with motive power designed for continuous service, and the light of much experience is needed before the conservatism of the steam railway world can be convinced that electricity can be commercially applied to trunk line operation. We may escape leaky boilers, poor coal and low steam only to find ourselves delayed by short-circuits, blown fuses, armature burn-outs, poor contacts, and other sources of failure; the snapping of overhead wires, and accidents to which powerhouse engines are liable—all are fraught with power to incur great inconvenience. The very concentration of the power supply in a few large prime movers makes any delay or accident all the more serious. The bursting of a single steam pipe may tie up a whole division—something most improbable with present methods of operating railways, where each engine carries its own power station upon its trucks. It is not easy to exaggerate the loss in time and money which would result from even an hour's blocking of the suburban traffic of a great railroad system like the New York Central through the failure of some small but important link in the chain of energy transformations which connects the power-house coal pile with the wheels of the electric locomotives. At the best, the adoption of electric motive power means increased complication of

equipment in power-house, line and substation, or distributing point, construction. There are many unsettled operating and maintenance problems which only experience can solve. The handling of suburban traffic of a city like New York or Boston, complicated as it is with transcontinental through travel, is a very different proposition from operating either street or elevated cars and trains."

So far as the matter of speed is concerned, the limitations in that direction are not altogether mechanical. The experiments upon the Marienfelde-Zossen military railway have demonstrated that under exceptionally favorable conditions an electric locomotive can make a speed which for a short time corresponds to a rate of 131 miles an hour, but that it is a very different thing from maintaining such speeds over long distances in regular service. It is now well understood that the limit of physical and nervous endurance is closely reached on steam locomotives with line speeds of 60 to 75 miles an hour, so that in this direction either type of motive power is well capable of meeting the practical requirements.

There is every reason to believe that electric traction on main-line railways will soon be given ample opportunity to show what it can do, and the result will doubtless be a process of evolution in the course of which the fittest will survive.

SPECIAL NICKEL-STEEL ALLOYS.

RECENT APPLICATIONS OF THE NICKEL-STEEL ALLOY OF MINIMUM EXPANSION IN GEODESY AND HOROLOGY.

Comptes Rendus—Nature.

WE have repeatedly referred in these columns to the interesting results which have been obtained with various alloys of nickel and iron, and more than three years ago a leading article was published in this magazine, by Professor Guillaume, to whom most of the information is due concerning the subject. We now have an account of the latest results in this important and interesting field of research in a paper by Professor Guillaume published in *Nature,* as well as a contribution by M. Mascart in a recent issue of *Comptes Rendus,* from both of which some abstracts are made.

The effect of the addition of a small percentage of nickel to steel in increasing the toughness of the product has been known and used by manufacturers for many years, but it was not until the scientific researches of M. Guillaume that the curious properties of the higher alloys were developed. These investigations of M. Guillaume were stimulated by certain observations concerning the physical properties of certain nickel-steel alloys, notably the fact noted by Dr. John Hopkinson, in 1889, that a ferro-nickel containing about 25 per cent. of nickel had its density reduced by about 2 per cent. after cooling to the temperature of solid carbon dioxide, and also the observations of M. Benoit, in 1895, upon an alloy of iron with 22 per cent. of nickel and 2 per cent. of cromium, this having a coefficient of expansion half as great again as that required by the law of mixtures.

The most apparent peculiarity of certain nickel-steel alloys was the fact that, although composed of two magnetic elements, some of them were not themselves magnetic except under certain conditions, and further investigation showed a relation between the properties of magnetism and expansion. These relations have been discussed at length by M. Guillaume, both in the article written by him in this Magazine in 1901, and in a more recent paper in the *Revue Générale des Sciences,* and his present paper deals more directly with the practical application of certain of the alloys, notably that containing 36 per cent. of nickel and 64 per cent. of iron, this being the alloy of minimum expansion. Because of its practical invariability in length under ordinary differences of temperature, this important alloy has been given the name of "invar" by Professor Thury, and under that name it is now generally known.

According to the diagram given by Professor Guillaume, the coefficient of expansion of invar is about 1 micron per metre per degree centigrade, or about one part in

one million, but a slight variation in the proportion of either element causes a rapid increase in the value of the coefficient, so that the greatest care is required in the manufacture of the alloy. Thus, the 27 per cent. alloy has about the same coefficient of expansion as iron, while a nearly proportionate rise occurs if the percentage is increased beyond the 36 per cent. nickel content. When the material is required for particular purposes, price being a secondary consideration, it has been found possible to select samples which have a zero or even a negative expansion, the alloy in the latter case actually becoming shorter for an increase in temperature.

These properties naturally indicated the adaptability of the alloy for the manufacture of standards of length, the troublesome temperature correction being eliminated. Careful experiments, conducted over considerable periods of time, have shown, however, that there is a slow, and very slight increase in length with the lapse of time, this increase being about 1/100 of a millimetre in five or six years, at ordinary temperatures, after which the subsequent yearly lengthening does not exceed a fraction of a micron. This action may be enormously accelerated by heating, so that bars may be seasoned in this manner, and their error from this cause almost entirely eliminated, but this fact renders the alloy unsuitable for use in the production of reference standards of the first order.

For working geodetic standards of length, however, invar has shown itself to be admirably adapted, especially in connection with the Jäderin system of base-line measurement with wires operated under constant tension. The old method of base-line measurement, using bars of moderate length, is slow and cumbrous, while the frequent repetition of readings multiplies in corresponding degree the element of observation errors. Unless the iced bar is employed, the temperature correction becomes an important matter, including all the difficulties of determining the true temperature of the bar, so that the operation is one demanding improvement. The original apparatus of Jäderin involved the use of two wires, one of steel and the other of brass, these being of the length of the standard tapes, usually 24 metres, or sometimes 100 feet, the ends being provided with short graduated scales. The wire, when used in measurement, is supported upon tripods at the ends, and strained taut by a constant weight, and it is possible by its use to measure a base fully 10 times as rapidly as with the bars formerly employed. By making the measurement simultaneously with wires of brass and steel the difference could be used as a measure of the mean temperature, from which the proper correction of the length given by the steel wire might be deduced. The application of wires made of invar to this method will readily appear, and trials were so encouraging that it was decided to use a single wire of the nickel-steel alloy for the base measurements in the Spitzbergen survey. An account of this work has already been given in these pages, and it has been shown by comparative measurements of the same base that the error was only 1/500,000, without any temperature correction whatever. Similar experiments in connection with the French equatorial survey in Ecuador have shown that the difference in the measurement of a base with a bimetallic scale and with a wire of invar was 1/3,300,00.

In order further to establish confidence in the reliability of wires of invar for geodetic measurements, a number of experiments have been made by MM. Benoît and Guillaume at the Bureau of Weights and Measures, more than a hundred thousand comparisons having been made during the past four years. In general, it may be stated that the introduction of this method of measurement has enabled base lines to be measured with an accuracy well within the limit of accuracy of the angular measurements, so that the general reliability of a survey may be controlled by the frequent and convenient measurement of base lines.

The communication of M. Mascart to the French Academy relates to the use of invar as a material for the pendulum of an astronomical clock. By the employment of the method of Lippmann of maintaining the impulses by electro-magnets it was found possible to use simple pendulums, without any compensation, in operation in closed cases under constant pressure, with a variation of 2 seconds in 24 hours. The experiments showed that the opportunity for error was greater in the mode of suspension than in

the effect of temperature changes, the use of invar rendering the gridiron or mercurial compensation unnecessary. The low cost of such pendulums renders them especially applicable for railway service and similar operative work.

Professor Guillaume also calls attention to the application of other nickel steels in horology. Thus the 24 per cent. alloy has the property of changing its modulus of elasticity with an increase in temperature, and this variation may be employed to compensate for the change in the elasticity of the spring of a watch at different temperatures. The use of a nickel-steel alloy in connection with the construction of the compensating balance of a chronometer has also resulted in a material improvement in the rate, this enabling the so-called Dent's error to be almost entirely eliminated. The ability to vary the coefficient of expansion by changing the composition of the alloy has rendered it possible to produce certain special metals of peculiar value. Thus, it has been found necessary to employ platinum wire for all electrical connections which involve the fusion of a wire into glass, because the expansion of platinum is practically equal to that of glass, and there is thus no tendency to crack the glass with any change of temperature. Attempts to use wires of other materials have been unsuccessful, since the glass always cracks around the wire. By using an alloy containing 45 per cent. of nickel, a coefficient of expansion identical with that of glass is obtained, and this material, to which the name platinite has been given, is already extensively used in connection with the manufacture of incandescent electric lamps.

In concluding his paper, M. Guillaume calls attention to two interesting features.

"All these applications which to-day give new resources to science and new economies, representing large sums, to industry, arise from a peculiar phenomenon of equilibrium in the mutual solution of two isomorphous metals; that is one interesting side of the question. There is another one on which I would insist in concluding; it is that these results have been obtained as a sequel to a long series of delicate measurements in which the thousandth of a millimetre was the ordinary unit, and without which no discovery in this domain would have been possible."

MAGNETIC FLUX DIAGRAMS.

INVESTIGATIONS INTO THE ANALOGIES BETWEEN HYDRODYNAMIC PHENOMENA AND MAGNETIC-FLUX DISTRIBUTION.

Institution of Electrical Engineers.

SOME of the difficulties which have been experienced by students and engineers in dealing with problems in electricity and magnetism have arisen from the uncertainty in the formation of correct mental conceptions of what actually takes place in connection with the distribution and behaviour of the invisible forces under consideration. For this reason it has been attempted more than once to derive mechanical or other concrete or visible analogies which might render clear the relations ordinarily expressible only by means of mathematical formulas. Thus, the very term electric current has grown out of the early idea that electricity was in some way analogous to a fluid, and that its passage along a wire might be conceived as something like the flow of a current of water through a pipe. In like manner the term pressure is used as equivalent to voltage, from the analogy between electrical pressure and the pressure of an elastic fluid under confinement. Such analogies must necessarily be used with caution, since there is no absolute warrant that they are complete, and occasional evidences show that they are not, but when checked by comparison with the theoretical treatment of the subject, and employed always with the clear understanding that they are only analogies, they may prove valuable auxiliaries in study and demonstration.

Recently some very interesting experiments have been made to represent, by hydrodynamic action, the phenomena which occur in the distribution of magnetic flux, with especial reference to the armatures of dynamos. The results of these experi-

ments have been embodied in a paper presented before the Institution of Electrical Engineers by Professor H. S. Hele-Shaw, Dr. Alfred Hay, and Mr. P. H. Powell. The nature of the paper is such that it requires for its complete presentation some reproductions of the interesting photographs, together with portions of the mathematical demonstration, but some abstract of the general method may be given here, together with the conclusions.

"The laws which govern the distribution of magnetic flux in space of two dimensions are identical with those which apply to the stream-line motion of a perfect incompressible fluid in two-dimensional space. If, therefore, we had such a fluid at our disposal, and by causing it to flow between parallel biunding walls determined the distribution of the stream-lines, this distribution would also represent that of the magnetic lines or tubes in a corresponding two-dimensional magnetic problem. This is the underlying principle of the hydrodynamical method as applied to magnetic problems. In trying to put the principle of this method into practice, we encounter the following difficulties:

"(1) The difficulty of mapping out the invisible stream-lines of the fluid. (2) The fact that there is no such thing as a 'perfect' fluid at our disposal, every actual fluid being more or less viscous. (3) The difficulty of finding an analogue for magnetic permeability, in order to enable us to study the flux distribution in cases where the field consists of regions having different permeabilities.

"The first difficulty is surmounted by using a colourless liquid into which are injected thin colour-bands, consisting of the same liquid mixed with a suitable dye.

"The second difficulty at first sight appears insurmountable. But a closer mathematical investigation by the late Sir G. G. Stokes has revealed the somewhat astonishing fact that when any viscous liquid is made to flow in a very thin layer between parallel bounding walls, *the stream-lines obtained are identical with those of a perfect liquid.*

"The third difficulty consists in devising a method by means of which the effects of varying magnetic permeability may be imitated. Now it may be shown, both theoretically and experimentally, that when a viscous liquid flows in a thin parallel layer, the quantity of liquid passing per second across a plane of unit length drawn normally to the stream-line is, for a given pressure grâdient inversely proportional to the cube of the thickness of the liquid layer. Hence, if the liquid is made to flow through several regions of different thickness, the ratio of the cubes of the thicknesses gives the ratio of the permeabilities in the corresponding magnetic problem.

"The practical method employed by us consisted in coating one of the thick glass plates forming the slide with a thin layer of paraffin wax, and then forming a cavity or cavities of the required shape by carefully scraping away the wax over certain areas. These areas, over which the liquid layer had a greater thickness, represented the regions of high permeability. The permeability varying in proportion to the *cube* of the thickness of the liquid layer, no difficulty was experienced in constructing slides in which the permeability over certain regions had as high a value as 1,000. The slide through which the liquid flowed being suitably illuminated, a photograph of it was taken, and thus a permanent record obtained of the particular stream-line distribution. The stream-line diagrams which accompany the present paper are reproductions of the photographs so obtained. The validity of the hydrodynamical method having been established, we proceeded to apply it to some problems in dynamo design whose solution has always been a matter of considerable difficulty. In order to render the investigation more complete, however, we decided to supplement the results obtained by the hydrodynamical method by experiments carried out on an actual dynamo fitted with several armature cores having different sizes of teeth and slots, and different air-gaps. In the calculation of the magnetomotive force required to produce a given magnetic flux in a dynamo having a toothed-core armature, the designer encounters two important difficulties. The first of these is the determination of the rêluctance of the air-gap, including the allowance to be made for the distortion due to the armature teeth and for the fringing effect around the edges of the pole pieces; and the second is

the determination of the reluctance of the teeth themselves. It is in connection with the first problem—that of air-gap reluctance—that the hydrodynamical method is of particular value."

It is evident that the distribution of magnetism is not the same in the case of a toothed armature as it would be for one with a smooth core. The teeth, however, are required for constructive purposes, and it is therefore important to be able to determine the extent to the disturbing influence due to the departure from the cylindrical form, and to make the corresponding correction before proceeding with the computations. The beautiful stream-line diagrams given in the paper, and projected upon the screen at its original presentation, show very clearly the deviation caused by the presence of the teeth, and the distribution of the lines enables the proper correction to be made.

"It is at once obvious, without the necessity of going into any elaborate investigation, that the presence of teeth in the armature core is equivalent to an increase in the gap length (or a reduction in the gap area); for the teeth disturb the uniformity of the flux distribution, causing a crowding of the lines into the regions of the polar surface which are opposite the teeth, and thereby increasing the fall of magnetic potential, from the polar surface to the crown of any tooth, above the value which it would have if the distribution were uniform (*i.e.*, if the core were smooth) and the total flux unaltered. Assuming that the exact effect produced by the teeth is known, a convenient method of applying the necessary correction consists in multiplying the gap length by a certain 'correction coefficient,' and then, using this corrected value, in proceeding with the calculation as if the armature core were smooth —*i.e.*, as if the flux distribution were uniform. The 'correction coefficient' clearly represents the ratio of the maximum to the mean induction.

"The value of this correction coefficient depends on the ratio of the width of slot to the top width of the tooth and to the length of the gap, and by a comparison of stream-line diagrams corresponding to various values of the two ratios a very good idea of the effect produced by the various kinds of teeth may be formed.

"The chief value of the diagrams, however, lies in the fact that they enable us to determine the numerical values of the correction coefficient in the various cases. All that is necessary for this purpose is to determine the number of stream-lines per unit of length in the space well under cover of a tooth, and to divide this by the mean number of stream-lines per unit of length for tooth and slot. Attention may be drawn to one or two features clearly exhibited by the diagrams. Two well-known effects are shown very plainly: the *refraction* of the lines as they pass from a medium of low into one of high permeability, and the crowding of the lines along the sharp edge of the tooth. It will be further noticed that between the straight lines in the region immediately above the tooth and the curved lines entering the slot and passing into the flank of the tooth, and exhibiting a concavity towards the tooth, there are certain intermediate or transition lines which are characterised by a point of inflection, the upper part of the line being concave and its lower part convex towards the tooth; the convexity gradually decreases as we take lines further and further away from the tooth, and is ultimately replaced by a concavity along the entire length of the line."

A check upon the correctness of the conclusions drawn from the stream-flow diagrams is given by the comparison with the theoretical researches of Mr. F. W. Carter, the tabulated results of the two methods agreeing very closely, and confirming the reliability of the method.

The paper also contains an account of investigations upon the reluctance of teeth in a slotted armature, this work being done upon a specially designed dynamo constructed for the purpose.

"The dynamo was of the single-bobbin type, with pole-pieces bored out to a diameter of 5½ in., and into the space between them could be introduced any one out of a set of five experimental armature cores. The cores consisted of sheet-iron stampings threaded on the shaft, and maintained in position by a feather key. The flux was determined by means of search coils at the top, the middle, and the bottom of a tooth. In addition to the three

coils surrounding the tooth, a fourth coil was used for the purpose of determining the total flux per tooth and slot, and the mean value of the gap induction. This coil was slung in the middle of the air gap.

"The reversal of flux was produced by a bodily rotation of the armature with its search-coils through 180°.

"In order to arrive at a correct estimate of the net cross-section of iron in the tooth, a large number of measurements was made of the thickness of the disks forming the different cores, and the number of disks in each core was carefully counted. The exact dimensions of the various exploring coils were also determined with great care."

The results of these investigations are tabulated in the paper, and also plotted in curves from which the effect upon teeth of different cross-section is shown.

"The ballistic measurements show clearly the steady increase in the magnetic flux as we proceed down the tooth—so long as the induction at the base of the tooth does not exceed about 20,000. Beyond this limit, another effect, not indicated by the stream-line diagrams (in which the permeability is constant), comes into play. The flux, after reaching a maximum value at a certain depth, begins to decrease, lines of induction leaving the flank of the tooth and crowding into the slot. This effect is very strongly marked for all the higher values of the gap induction.

"For the range of gap induction used, the curves connecting the total flux through the top and middle cross-sections of the tooth with the mean air-gap induction are almost straight lines through the origin. For the curves relating to the base of the tooth, the initial portion only is straight."

LOCAL ELECTRIC RAILWAY TRACTION.

THE USE OF ELECTRIC LOCOMOTIVES AND CARS IN THE TERMINAL AND SUBURBAN SERVICE OF THE ORLEANS RAILWAY.

Revue Générale des Chemins de Fer.

IT is becoming evident that the introduction of electric traction on main-line railways is not to be effected by any method of wholesale conversion, with all the upheaval and expenditure involved, and it is also apparent that the electric system is gradually making its way in a manner which will ultimately cause its extension to the greater part of railway operation. Already electricity has become supreme for local and tramway operation, and the development of interurban electric railways is a matter of recent record. For special purposes electric power is coming into use in various departments of standard railway operation, and it is to some of these that the extension of the system may be looked for.

One of the first applications of electric traction for main-line service is that of providing entrance into terminals in great cities where the smoke and gases of the steam locomotive has heretofore acted as a deterrent nuisance. All railroads desire to possess satisfactory passenger terminals as near the heart of the city as possible, and until the development of electric traction the public has been willing to put up with the accompanying inconveniences because no substitute could be found for the offensive steam locomotive. In cities where entrance was obliged to be made through tunnels, as in the cases of Baltimore, St. Louis, and New York, the advantages of electricity have been most apparent, and the use of electric locomotives in the Baltimore tunnel was the first practical application of the method for the hauling of standard main-line trains.

When it was decided to extend the line of the Orleans railway in Paris from the Pont d'Austerlitz to the new terminal on the Quai d'Orsay, through a tunnel running along the river bank, it was found necessary to use electric locomotives to haul the trains over the new portion of the line, and a full account of this important installation was given in the pages of this Magazine in April, 1899, by Prof. Boyer. More recently it has been determined by the New York Central and Hudson River Railroad to employ electric traction to bring its trains

into the terminal in New York City, this action being doubtless accelerated by the dangers and accidents accompanying the use of steam locomotives in the tunnel. The entrance of the Pennsylvania Railroad into New York City by means of a tunnel under the Hudson river has been made possible only by the availability of electric power for the traction service, and there is little doubt that the first and strongest hold of electric traction upon general main-line service will come by reason of the requirements of terminal conditions in great cities. In a recent issue of the *Revue Générale des Chemins de Fer* the development of electric traction upon the Orleans railway, following as a direct result of the use of electricity for the new terminal, is discussed in a paper by M. F. Paul-Dubois, and the subject is of sufficient importance at the present time to demand notice and review.

Since the introduction of electric traction upon the branch of the Orleans railway connecting with the new station in Paris, in May, 1900, the service has been in continuous and satisfactory operation. The electric locomotives haul from 150 to 200 trains daily, these ranging in weight from 150 to 350 metric tons, at speeds of about 50 kilometres per hour. This speed, corresponding to about 31 miles per hour, is limited by the operating conditions and not by the power of the locomotives, these being readily capable of double the speed, or more than 60 miles an hour, upon the clear and open line. The trains are taken from the steam locomotives at the Austerlitz station, and hauled to the Orleans terminal in 6 minutes, the times required for the substitution of the electric for the steam locomotives being uniformly less than 3 minutes.

Under these circumstances the management of the Orleans railway when called upon to increase the local traffic facilities, turned to electricity as a reliable means of traction, and the result has been the adoption of electric traction for the entire local service between Paris and Juvisy, a distance of 19 kilometres, or about 12 miles. In considering the change from steam to electric traction an important feature appeared in the gain in time due to the readier acceleration obtainable with electricity. Thus, with a train of 250 tons weight, stopping at all stations, there appeared a gain of 15 per cent. in time over the service of the powerful four-cylinder compound locomotives, and 25 per cent. over the ordinary local engines, this being entirely due to the prompt acceleration and not to higher running speed. Since it was the delay due to the numerous stops between Paris and Juvisy which retarded the general service, this portion has been converted to electric traction, using independent tracks on either side of the express track, and the relief gained by this arrangement has permitted the main steam service to be operated with satisfactory freedom.

The electric operation of the line calls for little comment, being principally an extension of the service which has proved so satisfactory during the past five years. A three-phase current at 5,500 volts is generated at the station at Ivry, this being transformed and converted to a continuous current at 600 volts for use on the line. Two substations are used, one at the generating station, and one at kilometre 13.45, these giving a convenient division of the distance.

The rolling stock included in the new service is of two kinds. For a portion of the work the electric locomotive has been found desirable, and these machines are similar to those which have proved so satisfactory in connection with the service of the Gare d'Orleans on the Quai d'Orsay. There are also a number of motor cars in use, these containing a cabin for the motorman, and compartment for baggage, and a number of third-class places for passengers. Two of these motor cars are used with each train, one at each end, the passenger cars being placed between, and all the motors being under the control of one man, by means of the Sprague multiple-unit system.

The introduction of electric traction on the Orleans railway has furnished also a convenient supply of electrical energy for a number of departments besides the traction service. Thus all the passenger and merchandise stations of the company within a radius of six kilometres are lighted from the central station; the water supply is furnished by electric power, both for the stations and the locomotives, and the handling is done by electric cranes, capstans, conveyors, etc. All the turntables and transfer tables are operated electrically, and numerous machine tools in the local repair shops

are electrically driven. Electric power is employed in the passenger stations both for elevators and lifts, and also for traveling platform conveyors for baggage, and the presence of a supply of electric current has led to its use wherever it can be conveniently applied.

The whole outcome of the original plan to use a few electric locomotives to haul the trains through the tunnel to the new terminal has been the development of a system of electric-power application which it would have been almost impossible to have introduced in any other way, but which it would now be impossible to displace in favor of any earlier system. It is in this way that electric traction on mail-line railways will come elsewhere; first, for services for which steam power cannot be used, then for local traffic, which demands expansion, then for gradual extensions, and last of all for the through-line express service, where the steam locomotive will doubtless make its last stand and for which it will probably continue to be employed for a comparatively long time.

LONG-DISTANCE POWER TRANSMISSION.

THE MAXIMUM DISTANCE TO WHICH POWER CAN BE ECONOMICALLY TRANSMITTED BY MEANS OF ELECTRICAL ENERGY.

Ralph D. Mershon—American Institute of Electrical Engineers.

PREDICTING is always an uncertain process, but it is often necessary to make a forecast in any line of work in which progress is to be expected, in order to enable the best method of work to be indicated. At the present time the development of long-distance electrical power transmission is the subject of careful study, and the papers presented at the St. Louis Electrical Congress, reviewed in these pages in November last, showed the interest which was there taken in the question. In a paper recently presented before the American Institute of Electrical Engineers, Mr. Ralph D. Mershon proposed to take up the question of the limitations of the electrical transmission of power, and while some of his conclusions may be open to question the value of the treatment is apparent.

"In endeavoring to make such a forecast, as will be here attempted, it should be borne in mind that each additional limitation consequent upon the assumptions necessary in order to obtain definite representative figures adds to the chance of the forecast proving erroneous. For instance, the first assumption which must be made is that in the future power will be transmitted in the same way as now. This may not hold. There may be devised some other and better way not involving the use of transmission lines. Such, however, does not appear probable. Other assumptions as to methods of construction being the same as, or similar to, those at present in use may be eventually so modified by skill and experience as to change very materially any conclusions arrived at now. This is less improbable. Conditions, industrial and financial, may so change that the constants now assumed as fixing costs, interest, etc., will be materially modified. This is probable. Finally, it is certain that with the course of time the value of power will increase, and this will materially alter any figures at which we may now arrive. The present conditions of practice and possibility are sufficiently definite, however, to warrant a forecast with the expectation that it will be applicable, approximately, at least, for some considerable time to come. At any rate, the method of treatment of the subject adopted will, with suitable changes in the values of constants, apply so long as present methods of power transmission obtain, and makes possible a comprehensive view of the possibilities of long distance transmission."

In the case of most attempts to discuss the subject the limiting element has been assumed to be some constructive or operative feature, but Mr. Mershon takes a wider view of the question, and shows that the limitations will come through economic considerations, as indeed they come with most engineering operations.

"The elements which, in the broadest sense, limit the distance to which power can be economically transmitted, are two; the cost of power at the generating station,

and the price which can be obtained for the delivered power. The difference between these two elements must cover the cost of transmission, the interest on the investment, and the profit. The cost of transmission comprises the loss of power in transmission, the cost of operating, and the cost of maintenance and repair. The value of the sum total of the interest which must be paid upon the investment, and the minimum profit which is considered satisfactory, will have much weight in determining the limiting distance of transmission. The less this sum is the farther power can be transmitted; a low interest rate and a low rate of dividend will, therefore, be conducive to long transmissions.

"Let us consider in a general way the manner in which the investment in a transmission plant and the annual charges and expenses in connection with the plant vary with different outputs, voltages, and distances of transmission. For a given voltage, drop, and distance of transmission, the cost of all the apparatus and equipment, except the line conductors, will increase more slowly than the output of the plant. That is, the greater the output of the plant the less the cost per kilowatt of all the equipment, except the line conductors. This will be true of the operating expenses also. Therefore, since the interest charges and the charges for depreciation and repair are dependent upon the investment, the greater the output of the plant the less will be the quantities going to make up the annual cost per kilowatt of transmitting power, except those depending upon the line conductors. Since the weight of the line conductors under the conditions assumed will vary directly as the amount of power transmitted, those elements of the annual cost per kilowatt depending upon the line conductors will be practically constant for all amounts of power transmitted and cannot be materially reduced by increasing the amount of power transmitted. With the same voltage, economic drop, and output, the elements of annual cost per kilowatt due to the line structure (pole line) and to its extent (patrolling, etc.), will increase directly at the distance. But, as outlined above, any increase of cost in line structure due to increase in distance can be offset by increase of output. On the other hand, the weight of the line conductors increases as the distance (for the same *economic* drop) and the elements of annual cost per kilowatt due to the weight of the line conductors will, therefore, increase as the distance, no matter what the output.

"It appears, therefore, that all the elements in the annual cost per kilowatt for transmitting power, except those dependent upon the line conductors, may be continually reduced by increasing the amount of power to be transmitted. The annual cost per kilowatt due to the line conductors cannot be so reduced. It can be diminished only by such other means as will reduce the first cost of the conductors. As the first cost of the line conductors can be reduced only by increasing the voltage of transmission and as there is a limit to which such increase can be carried, it follows that *the limiting distance to which power can be economically transmitted will depend, finally, upon the cost of the line conductors and upon this alone.*"

In order to determine what this limiting distance is Mr. Mershon makes certain assumptions, and while some of these are beyond the values of current practice they are by no means inadmissable. So far as the much discussed matter of voltage is concerned, he shows that this is not limited by physical considerations, such as difficulties of construction, air losses between conductors, insulation, and the like. Rather is it an economic matter, for it can readily be imagined that the voltage can be carried to such a high value that the line conductors will be reduced to such a point that the increased cost of transformers and insulators, due to further increase in voltage will overbalance any saving in line conductors.

Assuming that the power is purchased at $10.90 per kilowatt year, and sold at $34, with a profit of 12 per cent., Mr. Mershon derives formulas from which he computes the maximum commercial distance to be about 550 miles.

Although the assumptions in the computations by means of which this result was reached involved conditions not existing in present practice, they are not farther beyond them than present conditions are ahead of those of a few years ago, and there is no good reason to consider them

unattainable when they shall be required. At one time it was considered very desirable that electric power should be transmitted to long distances, but now it is realised that in most cases it is cheaper to place the manufacturing establishments closer to the source of power, and transmit the finished product to its markets. This may not always be the case, for all great water powers are not so conveniently situated as Niagara, and if the falls of the Zambesi are to be utilised, for instance, long distance transmission would be a necessity, at least for a long time to come.

Mr. Mershon is wise in stating the original conditions within which his forecast is made, since it is altogether possible that before the demand is made for transmissions of such magnitude and distance the methods may have become altogether changed. It is doubtless true that commercial and econoimic considerations will always rule in the ultimate analysis of any enterprise which depends upon commerce for its existence, but changing methods extend limitations in many ways. Thus any limitation in which the cost of the line wire is the ultimate element disappears at once if wireless transmission of energy becomes an accomplished fact, while the introduction of any such different system may bring with it other costs of a totally different nature. At the same time discussions such as Mr. Mershon has made are of great value, especially if they succeed in disposing of fictitious limitations, and direct the attention of engineers to the directions where improvements may best be made.

GLACIER PROTECTION WORKS.

REGULATION WORKS FOR THE CONTROL OF GLACIER STREAMS AND THE PREVENTION OF AVALANCHES IN UPPER SAVOY.

P. Mougin—Le Génie Civil.

ENGINEERING structures and operations have often been applied to control the movements of earth and regulate streams, and so it is entirely consistent that similar operations should be used to protect lands and habitations from the invasion of ice. In a recent issue of *Le Génie Civil* we note an article by Inspector Mougin, giving an interesting account of the works which have been made to guard against the dangers from the Tête-Rousse glacier, in Upper Savoy, and the subject is well worthy of notice and review.

The Tête Rousse glacier was almost unknown until the summer of 1892, being at the extreme south-west of the Mont Blanc chain, and separated from the greater and far more conspicuous basins of ice by the rocks of the Aiguille du Goûter, and by the larger Griaz Glacier. In July, 1892, the disaster of St. Gervais brought this glacier into notice by the sudden discharge of a torrent of water carrying a mass of débris down the valley in the middle of the night, destroying portions of the villages of Bionnay and Fayet, and the bathing establishment of St. Gervais, and causing a loss of 175 lives.

The glacier is not a large one, covering a little more than 10 hectares, or about 25 acres, but its peculiar position, filling an elliptical valley with but a limited outlet for the flow of ice causes it to offer material differences in behaviour from the action of the great glaciers having a free outlet for movement of ice and discharge of water.

Investigations by a party of engineers of the department of Streams and Forests led to the conclusion that some continuous outlet for the water from the Tête Rousse glacier was necessary for the prevention of further disasters, and the conduct of the work furnishes some interesting features in connection with this rather unusual department of engineering.

Vertical borings from the surface of the glacier showed that a body of water existed in the interior, and attempts were made to determine its depth by lowering weighted cords and measuring the wetted length of cord upon withdrawal. It was feared, however, that this method was unreliable, and suspected that the bottom of the cavity might be inclined so that the weight slid along until it met some obstruction, thus giving readings far too

great. Attempts to use jointed sounding rods were but partially successful, since the end of the rod also slipped along the icy incline at the bottom of the water, and breakages were frequent. Finally sufficient data were collected, and plans were made to bore a tunnel through the rocky wall of the valley and into the heart of the glacier, thus tapping the accumulated water and providing an outlet over and through the Bionasset glacier, where it could do no harm.

This portion of the work required great care in order that the imprisoned body of water should not be tapped at a time when its first efflux might carry away the men engaged in the tunnel, and it was only by boring test holes into the heading after the ice was penetrated that the approach to the water was determined.

In July, 1904, the tunnel reached the water, and the discharge, at first delivered through a small bore hole, finally flowed through the larger opening made for it until nearly 20,000 cubic metres of water had been drained off. The engineers were then able to enter the cavity, which formed a large cave in the interior of the glacier. It was found that the peculiar position of the glacier, preventing its forward movement, except at a far slower rate than the other ice bodies in the Swiss valleys, rendered it difficult for the water to escape, while the body of ice and its superincumbent layer of snow acted as a sort of jacketing, preventing the collected water from freezing, the temperature of the interior being practically constant at 0° Centigrade. The water therefore accumulated until its pressure became sufficient to burst through the front wall of the glacier, carrying destruction before it.

The completed tunnel forms an excellent protection work, since it drains the cavity continually, the flow being moderate in amount, and diverted toward a direction where no harm can be done. The whole undertaking is an excellent example of protective engineering of a special and important kind.

RAILROAD ACCIDENTS IN AMERICA.

THE PRACTICAL WORKING OF THE TRAIN-ORDER SYSTEM AND THE BLOCK SYSTEM ON AMERICAN RAILWAYS.

H. D. Emerson—New York Railroad Club.

THERE appears to be no doubt that the question of accidents on railways in the United States are increasing in number, and that the attention, both official and popular, which is at present being given to the subject is the direct result of the manner in which the facts have impressed themselves upon thinking men. The article by Mr. Haskell, published in our December issue, has been the subject of much comment, and from other directions come various articles and papers upon the subject. At a recent meeting of the New York Railroad Club a paper was presented by Mr. H. D. Emerson, discussing especially the part which the present methods of train dispatching bear to the increase in railroad accidents, and some abstract of the paper is given as forming a valuable contribution to this present question.

"The statistics of the Interstate Commerce Commission tend to show that accidents are becoming more numerous on American railroads than formerly; that is, that the proportion of accidents to passengers carried is increasing. The Board of Trade reports for Great Britain indicate that in that country the reverse is true. Setting aside all academic discussions as to whether the Commission includes, in its comparative tables, passenger miles, train miles, total density of traffic or train movements, or makes sufficient allowance for the different conditions in England and America, the fact remains that it is not becoming progressively more dangerous to travel on railroads in Great Britain and that the opposite is true of America."

In a brief historical review Mr. Emerson shows the difference between British and American methods of operation to have grown out of the early methods used in both countries. In America the early use of the telegraph, in connection with single-track roads, soon developed into the train-order system, the engineer having a regular

schedule for the siding and passing points, subject to telegraphed orders to do otherwise. In England, on the contrary, the germ of the block system appeared in the early use of a pilot man for each section, for whom a mechanical device in the form of the tablet or staff, was soon substituted, this leading to the use of mechanically operated semaphores.

Mr. Emerson discusses first the American train-order system, as applied to short, medium, and large lines, and shows very clearly how a method adapted for short lines and few trains becomes inadequate when extended to a scope far beyond its capabilities. In the case of a small road, of about 100 miles long, with two passenger trains, and one freight train in each direction a day, the operation is based on definite rules, easily memorized, and, in general, regularly obeyed. When a delay takes place, the dispatcher telegraphs to the conductor and engineer, and directs them to forget one particular thing which they had been instructed to remember at peril of death, and to remember something entirely new and different. This may not be a very serious thing on such a road as indicated, but when it is attempted to extend the same process to a line of 300 miles in length, with an average of five passenger trains and ten freight trains each way per day the possible number of meeting points for the passenger trains alone rises from four to twenty-five, and these must be memorized, again to be forgotten upon order. The number of crews, and the individual equation generally, will have risen proportionally much higher, and all attempt to retain any individual relations between the dispatcher and the train crews must abandoned. The result of this changed condition of affairs has been the evolution of the American Railway Association standard code, with its 23 rules and 13 forms especially applicable to single-track operation, all of which must be committed to memory by every dispatcher, agent, and trainman. Having these rules, the train order system still comes in to create confusion in case of emergency. If a train is, for any reason, delayed, orders are telegraphed by the dispatcher, and engineers, conductors, and brakemen, are alike required suddenly to forget the most vital and important lesson which they have learned, and to substitute for it a new lesson, to perform a new memory feat at peril of their lives. This is unquestionably the greatest weakness of the train-dispatcher's system. This is asking the man to sprint his distance in athletic competition and at the same time memorize his mathematical formulas—and not only memorize them, but put them into use while running.

When this system is extended to the case of a single-track main line, leading to the terminus of a large system, its break-down in case of emergency becomes inevitable. As Mr. Emerson says: train dispatching, as practiced, has elements of danger in excess of two to one at four different points, and at its worst the chances of wreck are simply terrifying to those who understand the possibilities. Turning now to the development of the block system in England its growth will be seen, with some reversals, to have progressed in the direction of safety instead of increased danger.

"After the traffic on the railroads in England became so congested that it could not be moved under the simple time-schedule arrangement, two methods were developed. The first is what is now known as the Tablet or Staff system. Under this arrangement the railroad was divided into sections or blocks, and each block was controlled by a tablet or staff. The engineman ran only when he had in his possession the staff which belonged to his particular block. This worked out so that the trains must be equal in number and must pass each other. That is to say, when a train was going north and the staff had been moved to the north end of the block no other northbound train could enter that block until the staff had been returned to the south end of the block. From this worked out the staff and automatic system whereby the agent at the end of the block retained the staff and gave to the engineman a ticket which permitted him to pass through the block. This provided that when a number of trains were moving consecutively in the same direction the last train carried the staff to the other end. This system developed some of the same dangers as the train dispatcher or time system and resulted in rear-end collisions.

"To obviate this difficulty and permit the freer movements of trains, the staff or tablet system was developed. This provides

for a box with a simple mechanical device at each end of the block, the two being electrically connected. Each box contains from ten to twenty tablets, or staffs. When one tablet or staff is removed from either box, both boxes are locked and no more tablets can be removed until the one in hand has been returned. Under this system the engineman knows absolutely that he has the sole right to the piece of track or block covered by the tablet or staff in his hand."

With increase in traffic manual blocking was adopted, both on single and double track roads, electric connection being provided between each end of the block. That systems on this basis are far more secure than the dispatching method is demonstrated by the small number of accidents occurring where it is faithfully employed. It has been objected to on the ground that it causes delays, but such an objection is simply to place convenience ahead of safety, and involves the admission that the length of the blocks is improperly calculated and the system imperfectly operated. It is true that wrecks have occurred on roads where the block system is used, but they are far less frequent, and as Mr. Haskell has observed, are largely due to failure to obey the requirements of the system.

"In England, with a much smaller mileage and a greatly denser traffic, fatalities are much less, proportionately, than they are in the United States. Is this not because the training of the engineman in the United States and the training of the engineman in England has been radically different? An English engineman has practically nothing to do with telegraphic orders. Before entering a block, and even before starting his train from a terminus, he knows definitely that the block is clear. He expects to be told by the indications of the signal: 'All right. Go ahead.'

"In operating on a single track with the tablet or staff system the very act of obtaining possession of the tablet or staff conveys to the English engineman a definite knowledge that he has the right to proceed. On the other hand, the American engineman has been educated to start his train on schedule time and to run and to look and to assume that everything is correct until he is told differently. Is it not true that his mental attitude of assuming that the signal will be clear when he shall reach it and that everything is right, causes many wrecks? If in each instance the engineman approached the block signal in a receptive frame of mind, expecting it to be against him and not passing it until he was definitely assured that it is not, would not a large percentage of the accidents which occur on blocked tracks be eliminated? The use of the staff system absolutely does away with the necessity of remembering orders or even of remembering the position of the signal at the end of the block. With the staff or tablet the engineman carries the signal with him, and he cannot only look at it and determine whether he has a right to be where he is, but he can also show it to others if he is called upon to prove his position."

CONDENSING MACHINERY.

THE DEVELOPMENT OF APPARATUS FOR THE PRODUCTION OF A VACUUM BY THE CONDENSATION OF EXHAUST STEAM.

William Edward Storey—Society of Engineers.

EVER since the invention of the separate condenser by Watt this portion of the power plant has been an important one, and although high-pressure non-condensing engines have been widely employed, the superior economy of the condensing engine has given it pre-eminence wherever sufficient water supply is available. In a paper recently presented before the Society of Engineers by Mr. W. E. Storey, the development of the condenser is examined at length, and some of the more important types now in current use compared.

In his original invention Watt seemed to have grasped nearly all the principles now in practical use, although he found the simple jet condenser and air pump best suited for operative conditions at his time. His original conceptions included the jet condenser with the wet air pump, the barometric condenser with the dry air pump,

and the tubular surface condenser, with separate air and circulating pumps.

"Jet condensers are of two types, the parallel-current, in which the steam and cooling water flow into the upper end of the condenser and are, generally speaking, withdrawn by one wet air pump; and the counter-current, in which the water and steam inlets are as far separated as possible, the former being withdrawn by a separate water pump and the air by a dry air pump. The first of these types will be recognised as the one largely adopted in slow-speed stationary engine practice.

"Although Watt foreshadowed the type of jet condenser in which the air and uncondensed vapour are drawn off by a separate air pump, leaving the water to be dealt with by other means, the practical development of the counter-current type, which has these distinguishing features, has only taken place during the last few years, notwithstanding that it possesses advantages in economy in construction and motive power as well as in efficiency. As has already been said, the dry air pump, in this type of plant, draws its charge from the top of the condensing chamber at a point adjacent to the cooling water inlet, whilst the exhaust steam enters the chamber low down and near to the outlet of the cooling water. Baffle-plates are arranged in the interior of the condenser to ensure the complete mixing of the steam and water; the air and uncondensed vapour as they rise meet water increasing in coldness, until, at the point of education to the air pump, they are at or about the temperature of the incoming water.

"The absolute pressure in the condenser is the sum of the pressures of the air and steam, and is the same throughout the condenser. At the point of discharge for the hot water, the steam pressure must be that —or approximately that—corresponding with the temperature of the hot out-flowing water. Here, however, the water temperature is at its highest, and, consequently, the absolute steam pressure is the highest also. The result is that the air pressure at the same point must be correspondingly low, and, owing to its extenuation, its volume relatively increased. At the point of air pump suction it will be seen that exactly opposite conditions prevail. The temperature being approximately that of the incoming cold water the absolute steam pressure is considerably lower, whilst the air pressure is higher, the air denser and greatly reduced in volume.

"The saving in volumetric capacity of the air pumps due to this arrangement, as compared with those required to produce equal results in the ordinary parallel-current jet condenser, is as much as 40 per cent. As the duty of these pumps is simply to compress air, the expenditure of power will also be reduced in about the same ratio. Hence with this system using pumps of equal volumetric capacity, a higher vacuum may be obtained, or for a given vacuum, smaller pumps may be employed."

"Although the parallel-current jet condenser is occasionally arranged with separate dry air pump, the disadvantage remains that the air and vapour are drawn into the pump at the temperature of the hot water and, therefore, at the point of their greatest possible volume, so that little benefit arises from this arrangement."

The idea of using the barometric principle for the removal of water is older than the time of Watt, having been employed to drain the cylinders of the early Newcomen engines in which the injection water was delivered directly into the cylinder and no air pump employed. After the inductive action of the jet was brought into prominence by the invention of the Giffard injector, it was seen that a properly designed combination of nozzles and barometric discharge tube would form an effective condenser without requiring any air pump, and a number of such condensers have been designed. Where the water can be supplied with moderate lift no water pump is demanded, the flow being maintained by the suction of the vacuum, but in other cases a pump is used, the load upon it being materially reduced by the aid of the vacuum. These condensers have been applied with much success, and in recent turbine installations a vacuum of 27 to 28 inches has been maintained, according to the atmospheric pressure at the time.

Another form of barometric condenser is the so-called counter-current type, already referred to as having been indicated by Watt. A modern form is the Weiss condenser, in which the air is allowed to

accumulate in the upper portion, to be drawn off by a dry air pump, while the water is carried off by gravity. Such arrangements are very efficient, and lower in first cost than the older types.

The surface condenser is the natural outgrowth of the desire to obtain a supply of pure water for boiler feed, this being especially important in marine navigation, where the salting of boilers is a serious objection to the use of sea water.

The early surface condensers were made with straight tubes fitted to a closed chamber, the circulating water passing through the tubes and the steam being delivered outside. The fact that the best results were not obtained with arrangement has led to the belief that the contact between the water and the surface of the tubes might be improved. It has also been maintained that there is a tendency for the air to remain in contact with the outside of the tubes, and thus keep the steam away from the cooling surfaces.

In modern condensers various attempts have been made to improve the performance in these respects. In the Wheeler condnser internal return tubes are used for the water, thus keeping the colder water in contact with the tube surfaces; other designs involve the breaking up of the water, either by the use of annular passages, as in the Paul condenser, or by means of corrugated plates, as in the design of Ljungström. The efficiency of such devices is understood when the relative quantities of water demanded are given.

Thus, for land service, where cooling water is often scarce, or of comparatively high temperature, a square foot of cooling surface is generally provided in the condenser for every 8 to 10 pounds of steam condensed per hour. In marine practice, with unlimited cold water available, a much higher duty, say from 15 to 20 pounds per square foot per hour, is expected, while with the Ljungström arrangement as much as 70 pounds of steam per square foot per hour is condensed.

Mr. Storey refers to the use of evaporative condensers and cooling towers for use where the supply of condensing water is limited, and also discusses the important matter of the corrosion and pitting of tubes. At the present time the corrosion of tubes is a question demanding solution, and the discovery of an alloy which can readily be drawn into tubing and which will not pit in service is greatly to be desired.

The construction and operation of various forms of air pumps is given attention in the paper, and a comparison of the early pump of Bodmer with the modern Edwards air pump shows that the advantage the principle was well known and clearly worked out as long ago as 1845.

"The great influence of a high vacuum on the steam consumption of the steam turbine has led to other devices for improving the vacuum being worked out by different engineers. Parsons has secured the desired result by dividing the air pump suction pipe into two parts, taking the water down one portion and the air down the other, the point of education from the condenser being for the latter, considerably higher in the condenser than that for the former. In the air pipe he inserts a steam jet which assists the air pump by partially compressing the air and vapour at the point of delivery to the air pump. By this means, whilst the vacuum in the condenser may be so high as 29 inches, at the inlet to the air pump it will be about 25½ inches, this result being effected by the use of a steam jet of an initial diameter of only 5-16 inch. It is obvious that with this simple device the efficiency of the air pump is greatly increased and that for a given duty its size may be relatively reduced."

"The improvement of the air pump efficiency by making the air and vapour more dense has also been attempted by other means. For instance, by retaining in the bottom of the condenser a body of the water of condensation, the temperature of which is kept below that of the vapour due to the pressure in the condenser, and then drawing the air and vapour to the air pump over the cool surface of this water, a somewhat greater density is secured for the pump suction charge; but it is problematical whether the contact of the air and the water is sufficiently intimate to produce a really appreciable result."

A comparison of the vacuum attained in the condenser with that realized in the cylinder has emprasised the importance of employing large exhaust pipes and free discharge of the steam into the condenser.

This is fully appreciated by the builders of steam turbines, the condenser, in more than one design, forming practically a continuation of the low-pressure end of the machine.

In connection with the subject of the production of vacuum for steam engines, we may call attention to the desirability of referring to the result in terms of absolute back pressure rather than in inches of vacuum. The fluctuations of atmospheric pressure, as shown by the barometer, render statements of vacuum in inches of mercury unavailable for comparison unless the statement of the height of the barometer at the time and place is also given. By taking the difference between the condenser and the atmospheric pressure at any time, expressed in pounds per square inch, we have the absolute back pressure in the same terms as the initial steam pressure, and data which are immediately comparable are obtained.

HIGH-SPEED MOTOR BOATS.

THE INFLUENCE OF POWERING, PROPELLERS, AND HULLS UPON THE SPEEDS ATTAINABLE WITH SMALL BOATS.

A. Tellier.—Société des Ingenieurs Civils de France.

APART from the importance of the development of mechanically propelled vehicles on common roads, the efforts to produce light and powerful motors for automobiles have resulted in effecting an unexpected influence upon other methods of locomotion. There is no doubt that the recent progress which has been made in dirigible balloons is entirely due to the improvements which have made possible the reduction in weight of the internal-combustion motor, and, in like manner, the so-called motor-boat, an unfortunate appellation for an otherwise nameless craft, owes its existence to the development of this same high-speed, light-weight engine.

In a paper presented recently before the *Société des Ingenieurs Civils de France* by M. A. Tellier, fils, some valuable information is given about the construction and performance of some small racing boats propelled by gasoline motors, and the manner in which the data and results are presented renders the information of more service than is usual. The trials recorded in the paper extend over a period of three years, and include information about boats of different designs, using various motors and propellers. Apart from the direct value of the information thus gathered, it may be useful for consideration in connection with the extravagant statements sometimes made, such as the prediction that internal-combustion motors may soon be expected to replace steam engines for torpedo-boat propulsion, whereas the largest engines of the internal-combustion type operating regularly in such boats do not exceed 150 horse power in capacity.

The first boat considered by M. Tellier is the Lutèce, built at the close of 1901. This is a vessel of 15 metres length, with a hull of cedar, having a displacement of two tons (metric), the hull itself weighing but 600 kilogrammes, or only 30 per cent. of the total displacement. The Lutèce was originally equipped with two four-cylinder Panhard motors, each of 40 horse power, arranged with a magnetic coupling and differential speed gear. The propeller had three blades, the generatrix being perpendicular to the axis, the diameter being 0.7 metre. Under these conditions, with both motors in operation, at a speed of 850 revolutions, a speed of 18.4 knots was attained. Although the weight of the motors was only 7.5 kilogrammes per horse power, this soon was found heavy by comparison with later machines, and in 1903 the boat was fitted with an improved Panhard motor, giving 80 horse power with one four-cylinder engine at 900 revolutions, this machine, including the fly wheel, weighing only 300 kilogrammes, or 3.75 kg. per horse power, or one-half that of the old motors. Although an improvement in working was apparent, the speed was not materially increased until the old propeller was replaced by an improved design, with increasing pitch, the generatrix being inclined 10 degrees aft to facilitate the contraction of the liquid vein. Under these conditions the speed attained was 19.5 knots, the trials giving the same result as had been attained by calculation.

M. Tellier gives some data concerning the boat La Rapée II, of 8 metres in length and a displacement of 0.8 metric ton, this making a speed of 16.25 knots with an indicated power of 33 h. p., and then proceeds to describe a still later model, La Rapée III, built in February, 1904. This hull is an example of the tendency to place the greatest cross section further and further aft, the hull resembling an elongated flatiron, with the greatest part at the stern. The midship section is almost circular, flattening rapidly toward the rear, the hull being absolutely flat at the stern. With this shape the water leaves the hull tangentially without showing either contraction or suction.

The Rapée III, with a length of 7.88 metres and a total displacement of 1.158 metric tons, made a speed of 18.4 knots. The motive power under these conditions was a Panhard-Levassor four-cylinder motor, giving 40 horse power at 900 revolutions, the weight being 5 kilogrammes per horse power. This engine was then replaced by one similar to that of the Lutèce, and a new propeller was also fitted. These changes were computed to make possible a speed of 21.8 knots, and this speed was attained on trial with 960 revolutions per minute of the engine.

M. Tellier gives data concerning trials of several other boats, including the Princesse Elisabeth, the Titan II, the Hotchkiss, and the Pertuisane, the results comparing well with those already cited. In general the progress made by reason of the experience of the past few years is clearly marked by these results. The reduction in weight is a notable element, and it is interesting to compare the Rapée III with the Turbinia, this latter boat representing the most remarkable results which have been attained with steam propulsion. Thus the Rapèe III has a powering of 80 horse power per ton of displacement, with a total weight-ratio of all machinery of only 6.25 kilogrammes per horse power. The Turbinia, on the contrary, has only 21.2 horse power per ton of displacement, and the machinery weighs 23.6 kilogrammes per horse power. If the Deutschland, for example, be compared with the Rapèe III by the law of similitude she would develop the enormous speed of 110 knots.

The principal criticism which has been made of the mechanical features of these little boats has been directed towards the motors. Their speeds of rotation have been considered enormous, ranging from 800 to 1,500 revolutions per minute, but, as a matter of fact, the actual piston speeds are lower than those of torpedo-boat engines or express locomotives, and the weight of the reciprocating parts is proportionally much lighter. M. Tellier maintains that such motors give little or no trouble in operation, and cites the fact that in the races at Monaco the engines of the Rapèe III were operated for six consecutive hours at 950 revolutions per minute, or a total of 342,000 consecutive revolutions, and, as there are four cylinders, there were 684,000 explosions. The speed of the boat over the sixteen laps of the course did not vary more than three seconds per lap, showing the uniformity of the motive power under these trying conditions.

M. Tellier considers that further improvements are to be looked for in connection with the design and construction of the propellers for the peculiar conditions required, and the results already obtained with these small screws at high rotative speeds gives encouragement for future improvement in this direction.

So far as the form of hull is concerned, it is interesting to note the differences which have developed in comparison with the models of high-speed steamboats. The practical results are altogether contrary to the famous wave-line theory of Colin Archer and Scott Russel, with sinusoidal bow and trochoidal stern. The facts are that the motor boat does not cut the water, and thus act to displace it; rather may it be said to plane the surface of the water, becoming thus a sort of hydroplane, analogous in design and action to that of the aeroplane. It is by a consideration of these differences in operating conditions that still higher speeds may yet be attained.

Down to the present time the improvements which have been made in these high-speed motor-boats have had the same end in view as in the case of automobile vehicles —the production of racing machines for sporting purposes. The recent endurance trials in England, however, have shown that such boats may be made useful auxiliaries for general marine and naval service.

CHROME-VANADIUM STEEL

IMPORTANT HEAT-TREATMENT EXPERIMENTS UPON ALLOY STEELS CONTAINING CHROMIUM AND VANADIUM.

Institution of Mechanical Engineers.

WE have referred in these columns to the experiments which have been made upon the influence of the addition of vanadium to steel, and the researches of M. Guillet have been especially considered as important. We now have a paper presented before the Institution of Mechanical Engineers by Captain H. Riall Sankey and Mr. J. Kent Smith, giving the results of some very important experiments upon steels containing both vanadium and chromium. The paper consisted largely of tabular matter, and it is impossible to give more than an abstract of the substance of the results in this place, but the remarkable character of the product gives much interest to the subject.

In the first place it appears that the addition of both chromium and vanadium to steel gives a product possessing in a very high degree the properties of strength and ductility. With an ultimate strength of 54 tons per square inch, and a yield point of 37 tons there was obtained an elongation of 25 per cent. in 2 inches, and an area reduction of 50 per cent. Under impact tests and rapidly alternating stresses according to the method of Professor Arnold results were obtained practically twice as high as those given by a good quality forging steel. The material was also subjected to metallographical examination, and especially to various forms of heat treatment, and it was mainly to this latter subject that the paper was devoted.

In the latter part of 1903 a paper was presented before the Iron and Steel Institute by Mr. J. E. Stead, and reviewed in these columns in November of that year. Briefly the method of Mr. Stead included the determination of a reheating temperature to which brittle steel should be raised, and from which it might be allowed to cool in the open air, this operation restoring it to proper working condition. This reheating temperature, according to Mr. Stead, is about 900° C., and it was his experience that any steel which had been made brittle by improper treatment could be completely restored by heating to about 900° C. for a short time and allowed to cool in the air, this operation making the material better, if anything, than it had ever been.

Applying this operation to the chrome-vanadium steel it was found that the ductility was increased, although the ultimate resistance was somewhat diminished. After such a treatment the ultimate resistance was 38.5 tons, the yield point 21 tons, while the elongation was increased to 34 per cent., with a reduction of area of 53 per cent. Both the torsional and the bending tests showed a material improvement, the material being fully as good as nickel steel. With these improvements come also increased resistance to alternating stresses and to impact, so that the material is in every way remarkable. These results are still further improved by oil tempering.

Thus, by oil quenching at 900° C. and then tempering at 600° C. an ultimate resistance of 53.6 tons is secured, with a yield point of 43.4 tons; the elongation being 22 per cent. and the reduction of area 56 per cent.

Experiments have also been made to show the applicability of these steels for cutting tools, and it appears that good cutting tools were made by heating to a high temperature and quenching, while a high grade of springs steels were also made of the material.

The utility of Mr. Stead's method of restoring burnt steel was fully demonstrated with the chrome-vanadium steel, specimens being soaked for several hours at 1,200° C., and shown to be seriously injured, and then fully restored by reheating.

An interesting feature about these tests was the care and thoroughness with which they were conducted. The heating was performed in an electrically heated muffle, this enabling the temperatures to be kept fully under control, while the temperature observations were made by means of an electric resistance thermometer, connected to a Callendar and Griffith record. The recalescence determinations, results of

which are given in the original paper, were obtained by the use of a carefully standardised couple, an efficient vacuum being maintained in the furnace chamber containing the piece of metal under observation, using a delicate galvanometer and a chronograph recorder. The tensile tests were made upon a Buckton 30-ton machine, with a Wicksteed recorder, and the alternation tests were conducted by Professor Arnold himself, so that the results may be accepted as trustworthy.

In the course of the discussion some additional points of interests with regard to the material were brought out. Thus, the resistance of the raw material to alternations was so good that no treatment was necessary, but if resistance to both alternations and impact are desired the steel should be annealed. The raw steel gives also extreme elastic resistance, combined with static ductility, while by annealing some of the static resistance is sacrificed to obtain static ductility and impact resistance. If both qualities are required it is necessary to resort to oil tempering.

In regard to the relative influence of vanadium and chromium upon the material, it was stated that experiments were made by using various chromium steels and then adding vanadium. With chromium alone very good results were obtained on static test, a strength of 38 tons being obtained with 1 per cent. of chromium. The simple addition of a small amount of vanadium increases the static strength about half as much again, and it was possible to get very much higher maximum strength by increasing the chromium.

The remarkable results which were shown by the tests tabulated in the paper, and the great interest apparent in the discussion may be taken as an indication of what may be expected in the further development of this question of alloy steels. With the materials now available for making ternary and multiple alloy steels there is such a large number of possible combinations that we may expect continual additions to the list of new materials of construction. Thanks to the electric furnace and to improved methods of isolation, materials which were formerly classed among the curiosities of the chemical laboratory and museum have become available for the production of new alloys in commercial quantities, and the results are only beginning to be appreciated. When to the supply of new material we add the command of improved apparatus, such as has been employed in the researches of the authors of the paper under review, enabling quantitative and controlled temperature effects to be produced, it will be realised that the scope of research is practically unlimited.

TESTING OF AMERICAN COALS.

A DESCRIPTION OF THE PLANT AND METHODS OF THE UNITED STATES GEOLOGICAL SURVEY AT THE ST. LOUIS EXPOSITION.

Prof. L. P. Breckenridge—Power.

NEARLY sixty years ago a number of tests of American coals were made by Professor Walter R. Johnson for the American navy, and it is a tribute to the accuracy of this work that the results have been accepted and generally confirmed by experience since that time. These tests, however, were limited in number and scope, and the need for something more modern and extensive has long been realized. Under these circumstances the fact that a new and complete series of tests of American coals was to be made at the St. Louis exposition, under the auspices and management of the United States Geological Survey, has found welcome and encouragement from mechanical engineers and steam users. This work is by no means completed, but from a paper in a recent issue of *Power*, by Professor L. P. Breckenridge, we give some account of the plant and the general method of operation.

The plans include tests of the coals under five different applications, namely: under steam boilers; in gas producers and gas engines; in coke ovens; in briquetting machines; and by chemical analysis and in the calorimeter. It will be seen, therefore, that

the data thus obtained will be of the greatest practical as well as scientific use, furnishing information as to the relative availability of various coals for different purposes, and also checking the results of laboratory methods by the larger scale trials in the actual processes of service.

The apparatus, described in detail by Professor Breckenridge, includes two Heine water-tube boilers of 210 horse power each, a gas producer, gas holder, and auxiliary apparatus, by R. D. Wood & Co., a three-cylinder Westinghouse gas engine of 250 horse power, coke ovens, briquetting plants, coal handling plant, chemical laboratory, Corliss engine, electric generators, and numerous electric motors, jigs, crushers, scales, boiler test appliances, and computing machines.

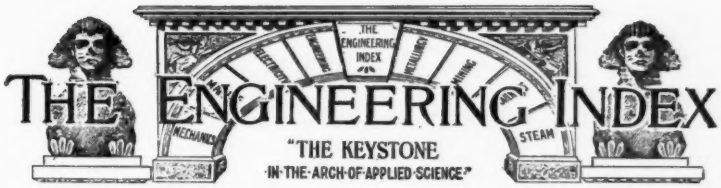
In the tests of coals under the steam boilers every care has been taken to render the conditions identical, so that the differences in the results may be those due only to the coals under test. The two boilers are set in exactly the same manner, and there are independent chimneys, and separate feeding apparatus. The testing is in the hands of a mechanical engineer in charge, under whom there are four observers in the boiler room—one for weighing coal, one for weighing the feed water, one for the general observations, and one for the gas analysis. The computations pass through the hands of two independent computers, in order that the results may be adequately checked. All the observers and computers are skilled men, of extended experience in similar work.

In general the methods indicated in the boiler test code of the American Society of Mechanical Engineers have been applied to the tests of the coals under boilers. The water and the coal are carefully weighed, the temperatures taken with standardized thermometers and pyrometers, while the draft readings are determined by carefully tested gauges. The flue gases, drawn for analysis, are taken by means of a sampling box arranged as closely as possible according to the method indicated in the code, using a number of tubes of different lengths in a box. Gas samples have also been taken simultaneously with a single perforated tube, with the object of determining the difference, if any, of the two methods.

The care which has been taken with all the details of the operation, and the publicity which has been given, is ample assurance that the work is being done with every care as to accuracy, and entire freedom from influence of private interests. The car loads of coal sent from the various mines have been certified to as to their origin and representative character, and the source kept unknown during the operations of testing, while the fact that the United States Geological Survey is responsible for the results gives an official character to the tests which frees them from any proprietary interests. The tests of coals under boilers are of ten hours' duration, so that ample time is given for a fair average result.

The conditions under which the machinery and apparatus were installed rendered it impossible for the work to be commenced before the latter part of August, and in consequence there is a general desire that it should not be discontinued because of the closing of the exposition. About fifty car loads of as many different kinds of coal have been tested, the varieties coming from widely separated fields and much of it from new fields. It is now hoped that a further appropriation may be obtained from the government for the continuance of this important work, and efforts are already being made to this end.

This question of the properties of standard coals is one of far-reaching importance, and it would be a matter of grave regret should the work so auspiciously begun be permitted to remain uncompleted. It is also undesirable that it should be conducted by means of private contributions unless the conduct of the work remains in the hands of the Geological Survey in such a manner as to give it the status of official government sanction. Apart from the classification of the coals by the calorific power, such a system of testing enables the best uses of the different fuels to be determined, and gives the engineer positive knowledge of the proper coals to use, not only for steam making, but also for use in metallurgical operations and for the production of fuel and power gas.



The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger division of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

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Concrete Abutment on the Ulster & Delaware. M. H. McGee. Illustrated description of a concrete abutment and long wing wall for a plate girder skew bridge. 500 w. R R Gaz—Vol. XXXVII, No. 25. No. 66445.

Drawbridge.

Details at the Pivot Pier and Ends of the Merrimac River Drawbridge, Newburyford, Mass. Illustrates and describes the operating mechanism, loading system and electric connections. 1400 w. Eng Rec—Dec. 17, 1904. No. 66689.

Frames.

The Computation of the Cross Frames of Iron Bridges (Beitrag zur Berechnung der Querrahmen Eiserner Brücken). F. Brunner. A very complete graphical analysis of the transverse stresses on bridge trusses for various loadings. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 9, 1904. No. 66824 D.

Highway Bridge.

The Schell Memorial Bridge. Illustrated description of a highway bridge across the Connecticut River at Northfield, Mass. 1500 w. Eng Rec—Dec. 17, 1904. Serial. 1st part. No. 66684.

We supply copies of these articles. See page 876.

The South Tenth Street Bridge, Pittsburg. Illustrated description of a five-span steel structure, 1,417 ft. long. 2000 w. Eng Rec—Dec. 10, 1904. No. 66612.

Plate Girder.

Erection of a Plate Girder Bridge with a Gin Pole. J. W. Philips. Illustrated description of an interesting work in connection with the Lackawanna improvements in Newark, N. J. 700 w. R R Gaz—Vol. XXXVII, No. 29. No. 66955.

Reinforced Concrete.

Concrete Steel Bridge at Plano, Ill.; Chicago, Burlington & Quincy Ry. Illustrated description of a double-track bridge 44 ft. wide, with an arch of 75 ft. span, and having wing walls which bring the total length to about 212 ft. 1400 w. Eng News—Dec. 22, 1904. No. 66763.

Reinforced Concrete Arch Bridges, Como Park, St. Paul. Illustrates and describes details of highway and pool bridges. 1000 w. Eng Rec—Dec. 3, 1904. No. 66471.

Structural Details of the New Reinforced Concrete Bridge at Grand Rapids, Mich. William F. Tubesing. Illustrated description of details of construction. 2300 w. Eng News—Dec. 1, 1904. No. 66422.

The Grünwald Bridge Over the Isar (Die Isarbrücke bei Grünwald). Prof. Mörsch. Detailed description of reinforced-concrete bridge, with two hinged arches of 70 metres span, across the Isar at Munich. Two articles. 4000 w. Schweiz Bauzeitung—Dec. 3, 10, 1904. No. 66848 each B.

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Rhine.

The Bridge Over the Rhine at Thusis. Illustrated detailed description of a steel bridge on the Albula Railway having a clear span of 80 m., and on each side an approach viaduct. 1000 w. Engr, Lond—Nov. 25. 1904. No. 66536 A.

Suspension.

Anchorages for the Manhattan Bridge. Illustrated description of the plans for the anchorages on both sides of the East River for the Manhattan Bridge between New York and Brooklyn. 900 w. R R Gaz—Vol. XXXVII, No. 27. No. 66671.

CONSTRUCTION.

Beams.

Kinematic-Statical Treatment of Cantilever Beams (Kinematisch-Statische Untersuchung eines Balkontragers). G. Ramisch. A mathematical investigation of the forces acting upon projecting and cantiliver beams. 3000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 11, 1904. No. 66817 D.

The Theory of the Semicircular Cantilever (Zur Theorie der Halbringförmigen Balkonträger). Johann Stutz. A mathematical analysis of the forces in a projecting beam for the support of a semicircular balcony. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 2, 1904. No. 66823 D.

Building Construction.

The Erection of the Trinity Building, New York. Illustrated description of a building under construction adjacent to Trinity Church, of great height and of special interest. 2000 w. Eng Rec—Dec. 3, 1904. No. 66476.

Excavating.

Electric Railways for Grading Work. An illustrated article describing the carrying away of the excavated material in trolley cars operated over temporary tracks, to fill the marsh lands. 2500 w. Eng Rec—Dec. 24, 1904. No. 66781.

Excavating and Conveying Machinery in Contract Work. C. H. Wright. A discussion of the cost reductions which have been effected by the use of machinery in earthwork and general construction. 4000 w. Engineering Magazine—Jan., 1905. No. 66890 B.

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Rebuilding the Campanile of Venice. Notes by F. Hopkinson Smith on the progress of the reconstruction of the foundations. 1200 w. Eng Rec—Dec. 3, 1904. No. 66474.

The Development of Shallow and Deep Foundations for Chicago Buildings. On the foundation problem to meet the conditions in Chicago, the past and present practice. Ills. 5000 w. Eng News—Dec. 22, 1904. No. 66764.

The Foundations for the Yonkers Power House of the New York Central & Hudson River R. R. Illustrates and describes the present stage of one of the two stations to furnish electricity for handling the N. Y. Central's train service near New York. 2700 w. Eng Rec—Dec. 10, 1904. No. 66611.

The Stability of the Foundations of the Union Ferry Depot in San Francisco. Frank Soule. Abstract of expert's report after careful examination and tests made. Ills. 1500 w. Cal Jour of Tech—Oct., 1904. No. 66417 C.

Industrial Buildings.

The Engineering of Industrial Buildings. D. C. Newman Collins. Discusses the development of building plants, the cost of maintenance, etc. 2500 w. Ir Age—Dec. 1, 1904. No. 66468.

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The Protection Works Recently Executed at the Tête Rousse Glacier (Glacier de Tête Rousse—Travaux de Protection

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Récemment Exécutés). P. Mougin. Describing the manner in which a tunnel was bored beneath the glacier to carry off the undermining water. 2500 w. Génie Civil—Nov. 12, 1904. No. 66800 D.

Reinforced Concrete.

A Concrete Steel Dam at Danville, Ky. Illustrated description of an interesting dam built across the Dix River to impound a water supply. 700 w. Eng Rec—Dec. 3, 1904. No. 66478.

A 182-ft. Chimney of Reinforced Concrete at Bellevue, Mich. Illustrates and describes a structure having interesting features. 900 w. Eng News—Dec. 29, 1904. No. 66939.

Construction and Strength of Reinforced Concrete Columns. W. Dunn. Considers the necessary tests to secure reliable material and the strength of the material in place, giving results of experiments, etc. 9800 w. Jour Roy Inst of Brit Archts—Nov. 26, 1904. No. 66931 D.

Design for Reinforced Concrete Retaining Wall. F. F. Sinks. An illustrated description of a design, with statement of assumptions and methods. 800 w. R R Gaz—Vol. XXXVII. No. 29. No. 66953.

Construction and Strength of Reinforced Concrete. W. Dunn. Read before the Roy. Inst. of Brit. Archts. Abstract. Deals with the essentials of reliable material, the process of mixing, the strength, method of construction, etc. 1800 w. Archt, Lond—Nov. 25, 1904. No. 66522 A.

Monolithic Constructions in Hennebique's Ferro-Concrete. L. G. Mouchel. An illustrated discussion of ferro-concrete constructions and the general principles on which they are based, the theory of the Hennebique system, the use of this material, and related matters. Ills. 7500 w. Jour Roy Inst of Brit Archts—Nov. 26, 1904. No. 66932 D.

Directions for Making Concrete-Steel Slab Culverts and Bridges. Abstracted from Bul. No. 7, N. Y. State Engineer. Directions for the work, illustrating details. 800 w. Eng News—Dec. 29, 1904. No. 66941.

Six-Story Reinforced-Concrete Factory Building in Brooklyn. Illustrates and describes a fireproof structure designed to carry light machinery on every floor. 1800 w. Eng Rec—Dec. 10, 1904. No. 66613.

The Reinforced Concrete Building of the J. M. Bour Co., Toledo. George V. Rhines. Illustrations, with description of a warehouse and roasting plant constructed entirely of concrete reinforced with plain steel rods. 2700 w. Eng Rec—Dec. 24, 1904. No. 66782.

See Also Civil Engineering, Bridges.

Retaining Wall.

A Concrete Wall Eleven Years Old. Illustration and data in regard to a retaining wall on the Coast division of the Southern Pacific. 900 w. R R Gaz—Vol. XXXVII. No. 26. No. 66557.

See Also Reinforced Concrete.

Roads.

The Oiled Roads of California. Information from a recently issued bulletin presenting all the available data in regard to oiled roads in the State. 5000 w. Eng Rec—Dec. 1, 1904. Serial. 1st part. No. 66477.

MATERIALS OF CONSTRUCTION.

Cements.

Natural Hydraulic Cements. E. C. Eckel. Discusses the natural cements as a class, noting the points of resemblance of the various brands. 1800 w. Munic Engng—Dec., 1904. No. 66654 C.

The Constitution of Portland Cements from a Physico-Chemical Standpoint. Clifford Richardson. Address before the Assn. of Portland Cement Mfrs. Reviews the work of Le Chatelier and Törnebohm, and other investigators, with account of the author's work. 5000 w. Sci Am Sup—Dec. 10, 1904. Serial. 1st part. No. 66559.

What Can Chemical Research Do for the Portland Cement Industry? Extracts from an address by Mr. Clifford Richardson at the annual dinner of the Assn. of Portland Cement Mfrs. Considers how chemical research can be best carried on, and some of the problems it may be depended upon to assist. 3000 w. Eng Rec—Dec. 24, 1904. No. 66786.

Efflorescence.

How Can Efflorescence on Concrete Be Prevented? An explanation of the phenomenon of efflorescence, with a discussion of methods of prevention or cure. 1300 w. Eng News—Dec. 22, 1904. No. 66766.

Hardening.

The Conditions Hydration and Hardening (Ueber Hydratations und Erhärtungsvorgänge). Dr. P. Rohland. A study of the conditions of hardening of plasters, cements, mortars, etc. 4000 w. Zeitschr f Elektrochemie—Nov. 25, 1904. No. 66875 D.

Timber.

The California Redwood in Modern Engineering. H. A. Crafts. An account of some of the uses to which the redwood is put in California. Ills. 1000 w. Sci Am—Dec. 3, 1904. No. 66451.

The Strength of Structural Timber. A summary of the investigations being made by the U. S. Dept. of Agriculture, under the direction of W. K. Hatt, with editorial comment. 2600 w. Eng Rec—Dec. 24, 1904. No. 66783.

We supply copies of these articles. See page 876.

Timber: Its Strength, and How to Test It. Prof. T. Hudson Beare. Abstract of a lecture delivered before the Dundee Inst. of Engrs. Gives tabulated report of tests made, with remarks on previous investigations, and the value of tests. 1000 w. Engng—Dec. 9, 1904. No. 66731 A.

MEASUREMENT.

Grain Pressure.

Tests of Grain Pressure in Deep Bins at Buenos Ayres, Argentina. Eckhardt Lufft. Gives a summary of results of tests carried out from Feb. to Nov., 1903. Ills. 3000 w. Eng News—Dec. 15, 1904. No. 66662.

Stream Gagings.

Notes on the Computation of Stream Gagings. O. V. P. Stout. An explanation of the Harlacher method of computing discharge. 1000 w. Eng News—Dec. 8, 1904. No. 66555.

The Measurement of Running Water in Rivers and Open Channels. W. H. Wheeler. An illustrated article reviewing methods of estimating, and especially considering recent work in the United States. 5000 w. Engr, Lond—Dec. 9, 1904. No. 66733 A.

Stadia.

The Stereoscopic Measuring Apparatus (Das Stereoskopische Messverfahren). A. Freiherr v. Hübl. Describing the application of exaggerated stereoscopic effects to the measurement of distances, with especial reference to the apparatus of Dr. Pulfrich. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 25, 1904. No. 66820 D.

Surveying.

How the Massachusetts Northern Boundary Was Run Without Random Lines. N. Spofford. An account of the use of tall signal poles through land covered with a heavy growth of wood and timber. 2000 w. Eng Rec—Dec. 10, 1904. No. 66616.

The Three-Point Problem in Plane-Table Surveying. Antonio Llano. Describes Bessel's method for the graphic solution of this problem in the field. 1500 w. Eng News—Dec. 29, 1904. No. 66944.

Topography.

Stereoscopic Topography (Sur la Télésteréoscopie). Paul Helbronner. An account of the application of stereoscopic photography with telephotographic lenses to views in the French Alps to aid in topographical work. 1500 w. Comptes Rendus —Dec. 5, 1904. No. 66845 D.

MUNICIPAL.

Address.

Municipal Engineering on the Continent. W. H. Lindley. Summary of the presidential address to the Junior Inst. of Engrs. Considers waterworks, sewerage works, electric lighting, and other works. 2700 w. Mech Engr—Nov. 26, 1904. No. 66525 A.

Cesspools.

A Successful Dry Well. An illustrated description of a sanitary arrangement for taking care of house sewage where no sewers are available. 1200 w. Met Work —Dec. 3, 1904. No. 66447.

Refuse Destruction.

See Mechanical Engineering, Steam Engineering.

Septic Tanks.

Septic Tank Sewage Disposal. A record of the practical working of the system, based on six years' experience. 3000 w. Munic Jour & Engr—Dec., 1904. No. 66485 C.

The Septic Tanks at Greensboro, N. C. W. G. Potter. Brief description of the construction of septic tanks where peculiar difficulties were encountered. Ills. 1200 w. Eng Rec—Dec. 10, 1904. No. 66614.

Sewers.

Sewer Reconstruction in Connection with the New York Rapid Transit Subway. An account of the difficult work of diverting and replacing the sewers on the line of the subway. 2700 w. Eng Rec—Dec. 17, 1904. No. 66688.

Sewer Siphons in Brooklyn, N. Y. Illustrates and describes some interesting details of design and construction made necessary in rearranging the sewers on the line of the rapid transit subway. 1400 w. Eng Rec—Dec. 3, 1904. No. 66472.

The Main Intercepting Sewers of Cleveland, Ohio. Walter C. Parmley. An account of this undertaking and some of the engineering features and problems connected with it. Ills. 9500 w. Jour Assn of Engng Socs—Nov., 1904. No. 66698 C.

The Sewers of Little Rock, Ark. E. A. Kingsley. Concerning the sewerage system and drainage. 1000 w. Munic Engng —Dec., 1904. No. 66655 C.

Tools Used in Cleaning Sewers. Ben. E. Briggs. Illustrates and describes tools used at Erie, Pa. 900 w. Munic Engng— Dec., 1904. No. 66653 C.

Towns.

The Construction of Towns. Prof. L. Cloquet. Deals with the planning of a town, the street design, and the public places. Plans. 3000 w. Engng Rev—Dec., 1904. Serial. 1st part. No. 66720 B.

WATER SUPPLY.

China.

Shanghai Water-Works. Illustrated description of the pumping station and a set of engines which have recently been in-

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stalled. 2500 w. Engr, Lond—Dec. 16, 1904. No. 66928 A.

Conduits.

The Wood-Stave Conduit for the Water Supply of Atlantic City. Kenneth Allen. An illustrated detailed description of the construction work, with notes and discussion. 6500 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66750 F.

Filtration.

The American System of Filtration Plant in Mysore, India. Edmund B. Weston. An illustrated description of the works for supplying the Kolar gold field with potable water. 4500 w. Eng Rec—Dec. 17, 1904. No. 66682.

The Philadelphia Filtration System. Illustrated detailed description of the siphon of the Torresdale tunnel conduit, which carries the filtered water to Lardner's Point. 3000 w. Eng News—Dec. 1, 1904. No. 66423.

Holyoke.

The Holyoke Water Supply. A. M. French. Gives the history of its conception, birth and continuous growth up to its present magnificent system. Map. 6300 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66751 F.

Irrigation.

Tests of Irrigation Pumping Plants and Wells in the Valley of the Rio Grande. Charles S. Slichter. Describes tests made in New Mexico and Texas, giving tabulated results. 2500 w. Eng News—Dec. 29, 1904. No. 66940.

Mains.

Laying a Submerged Water Main at Waterville, Me. Illustrates and describes the unusual method used in laying a 20-in. water main under the Kennebec River. 1000 w. Eng Rec—Dec. 17, 1904. No. 66687.

New York.

Additional Water Supply for New York City. Rudolph Hering. An interesting statement of the conditions in Greater New York, with report of recent investigations in regard to future increase of the supply, the quality of the water, cost, etc. Map. 5400 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66749 F.

The Condition of the Croton Water-Works, New York. Gives a diagram showing graphically the value of work done each year from 1895 to 1904, inclusive, with comments on the information given in the recent report of J. Waldo Smith, chief engineer. 2500 w. Eng Rec—Dec. 24, 1904. No. 66784.

Reservoirs.

Failure of a Reservoir Bottom at Red Wing, Minn. F. H. Bass. Brief illustrated description of a peculiar failure. 500 w. Eng News—Dec. 8, 1904. No. 66556.

Revenue.

Municipal Water Supply Revenue. James L. Tighe. Discusses the equity of using this revenue for meeting the expenses of government. 2700 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66748 F.

Stand Pipe.

A Stand Pipe Failure at Sanford, Me. Charles W. Sherman. An illustrated account of the failure of a 40 x 80 ft. steel stand pipe on Nov. 17, 1904. 1000 w. Eng News—Dec. 1, 1904. No. 66425.

Turbidity.

A New Method for Determining the Color of the Turbidity of Water. Freeland Howe, Jr. Describes a method by which the color can be expressed mathematically and can be reproduced at any time or place. 1200 w. Eng Rec—Dec. 17, 1904. No. 66686.

Typhoid.

The Epidemic of Typhoid Fever in Ithaca, N. Y. George A. Soper. Gives statistics of this epidemic, discussing the theories of the cause and the corrective measures undertaken. Discussion. 11200 w. Jour N Eng W-Works Assn—Dec., 1904. No. 66753 F.

The Longevity of the Typhoid Bacillus in Water. George C. Whipple. Reviews recent papers by Dr. William Dodge Frost, and a joint paper by Dr. E. O. Jordon, Dr. H. L. Russell, and Dr. F. R. Zeit. 4000 w. Eng Rec—Dec. 24, 1904. No. 66785.

Water Rights.

Water Rights in California. Samuel C. Wiel. The present article reviews the history of the law of water in California. 1500 w. Min & Sci Pr—Dec. 17, 1904. Serial. 1st part. No. 66795.

WATERWAYS AND HARBORS.

Alexandria.

The Harbor of Alexandria (Le Port d'Alexandrie). G. Birault. An account of the development of the modern port since 1832, and of the present and projected harbor improvements at Alexandria, Egypt. 3000 w. Génie Civil—Dec. 10, 1904. No. 66825 D.

Canals.

A Description of the Truckee Main River Canal. George Shuey. An illustrated description of this irrigation project in Nevada. 1700 w. Cal Jour of Tech—Oct., 1904. No. 66419 C.

The British Canals Problem. Arthur Lee. Discusses the policy adopted on the Continent, and the policy of the British Railway Companies, and the importance

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of the matter. General discussion follows. 11500 w. Jour Soc of Arts—Dec. 2, 1904. No. 66620 A.

The Lesson of the German Water-Ways. O. Eltzbacher. A comparison of the cost of transport in Germany and Great Britain, showing the value of waterways, and discussing other causes tending to industrial success. 8500 w. Contemporary Rev—Dec., 1904. No. 66715 D.

Electric Haulage.

Electric Haulage in Germany. Clarence B. Schultz. Facts concerning the Teltow Canal, near Berlin, Germany, describing the system of traction, the machinery adopted, etc., giving a financial review of the different electric haulage systems. Ills. 4000 w. Marine Engng—Dec., 1904. No. 66548 C.

Locks.

Canal Locks Considered as Inclined Planes (Ueber Schleusentröge auf Quergeneigter Ebene). Fr. Jebens. A consideration of the inclination of the surface of the water in canal locks, due to the effect of the movement of the water. 1500 w. Glasers Annalen—Dec. 15, 1904. No. 66831 D.

Panama.

The Present Aspect of the Panama Canal Construction. Wm. H. Burr. A general account of the existing conditions and plans for work at the isthmus. 3500 w. Engineering Magazine—Jan., 1905. No. 66888 B.

Pier.

The Landing Pier at Lome (Die Landungsbrucke in Lome). K. Preiss. A fully illustrated description of the erection of a steel pier at Lome, on the west coast of Africa, in the German colony of Togo. 3500 w. 2 plates. Zeitschr d Ver Deutscher Ing—Nov. 26, 1904. No. 66812 D.

Stream Beds.

The Natural Equilibrium of the Beds of Flowing Streams (Untersuchung über die Naturliche Gleichgenrichtform Beweglicher Flussbetten). F. Kreuter. A discussion of the proper form to be given to artificial river banks in regulating and controlling streams. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 25, 1904. No. 66821 D.

Trieste.

The Harbor of Trieste (Der Hafen von Triest). Eduard Michl. A general account of the development of the port, with description and plan of the proposed improvements of the harbor and railway terminals. 4000 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—Nov. 11, 1904. No. 66816 D.

MISCELLANY.

Japan.

Notes of an Engineer in Japan. W. E. Crane. Briefly describes the irrigation works, canals, railroads, highways and bridges, water supply, sanitation, garbage disposal, buildings, etc. 2500 w. Eng News—Dec. 29, 1904. No. 66945.

ELECTRICAL ENGINEERING

COMMUNICATION.

Automatic Telephones.

Is the Automatic Telephone System Best for the Telephone Patron? P. Kerr Higgins. Read before the Engrs. & Archts. Assn., Los Angeles, Cal. Reviews briefly the features of both systems, and discusses the requirements of a successful automatic system. 2000 w. Elec, N Y—Dec. 7, 1904. Serial. 1st part. No. 66515.

Line Protection.

Commercial Aspects of Telephone Line Protection. Kempster B. Miller. Considers where and under what conditions protection should be given, and under what conditions it is better to take some risk and give only partial protection or none at all. 2500 w. Elec Rev, N Y—Dec. 10, 1904. No. 66590.

Selenium.

Selenium and Its Applications in Light Telephony (Ueber das Selen und Seine Bedeutung für die Elektrotechnik unter Besonderer Berücksichtigung der Lichttelephonie). Ernst Ruhmer. A long paper upon the application of selenium for converting light waves into electricity. 7000 w. Elektrotech Zeitschr—Dec. 1, 1904. No. 66864 B.

Signals.

The Use of Telegraph Lines for Signal Conductors (Telegraphenleitungen als Rückleitungen für Signalleitungen). A. Prasch. Describing experiments made on the Austrian railways without interfering with the use of the wires for telegraphy. 2500 w. Elektrotech Zeitschr—Dec. 8, 1904. No. 66866 B.

Space Telegraphy.

An Electrolytic Wireless Telegraph Detector. Dr. James E. Ives. An account of experimental investigations to determine the precise nature of the action of the electrolytic oscillation detector, described by Dr. Lee de Forest in a paper before

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the Int. Elec. Cong. at St. Louis. 3000 w. Elec Wld & Engr—Dec. 10, 1904. No. 66560.

A New Magnetic Wave Detector (Neuer Magnetischer Wellenempfanger). W. Peukert. Describing the application of a detector using the principle of the hysteresis of iron in a varying magnetic field to the reception of waves in space telegraphy. 1200 w. Elektrotech Zeitschr—Nov. 24, 1904. No. 66861 B.

Experiments on the Reception by Wires of Electric Waves. C. A. Chant. An account of experiments made in connection with the receiving antenna as used in the Braun, Siemens & Halske system of wireless telegraphy, the radiation from transmitters, the effect on resonance of inserting a coherer in an open wire, &c. 3000 w. Am Jour of Sci—Dec., 1904. No. 66649 D.

The Erection of a 180-Foot Mast for Wireless Telegraphy and Telephony. Joseph B. Baker. An account of the erection of a mast built of three wood spars, near Boston. Ills. 2400 w. Elec Wld & Engr—Dec. 24, 1904. No. 66799.

Telautograph.

The Telautograph. Illustrated description of the automatic reproducing telegraph constructed by the National Gray Telautograph Co., of New York, explaining its operation. 1000 w. Engng—Dec. 2, 1904. No. 66637 A.

Telegraph.

The Pollak-Virag Rapid Telegraph. An illustrated explanation of the working of this system. 1200 w. Engr, Lond—Dec. 16, 1904. No. 66927 A.

Telephone Lines.

A New Danger to Telephone Lines. J. C. Kelsey. Discusses troubles that may come with the use of the grounded alternating trolley system. 2500 w. Elec Rev, N. Y.—Dec. 17, 1904. No. 66709.

Telephony.

Fundamental Principles of Power Equipment for Telephone Exchanges. B. D. Willis. Discusses in detail the fundamental parts of telephone power plants. 2200 w. Elec Wld & Engr—Dec. 17, 1904. No. 66710.

The Chicago Telephone Company's "Juice Wagon." An illustrated description of the method of thawing out frozen laterals. 2000 w. Elec Wld & Engr—Dec. 10, 1904. No. 66562.

The Cost of Telephone Service in a Farming Community. H. Sprague. Gives figures drawn from American practice, in regard to the actual cost of operation. 2800 w. Elec Wld & Engr—Dec. 10, 1904. No. 66563.

The Principles of Exchange Telephony. Herbert Laws Webb. A discussion of some of the details of telephone service and the principles of operation. Considers the proper unit of the local service to be the message, and discusses signaling, economy, rates, &c. 6500 w. Cassier's Mag—Dec., 1904. No. 66458 B.

The Quality of Telephone Service. Samuel G. McMeen. Discusses the elements that contribute to making the service satisfactory. 2800 w. Elec Rev, N. Y.—Dec. 17, 1904. No. 66708.

Testing.

See Eectrical Engineering, Measurement.

DISTRIBUTION.

Buffalo.

Niagara Power in Buffalo. The first of a series of articles dealing with the distribution of electrical energy by the Cataract Power & Conduit Company, the cost, equipment, &c. 4400 w. Elec Wld & Engr—Dec. 3, 1904. Serial. 1st part. No. 66508.

Cables.

Tables for the Loading of Simple Continuous-Current Cables (Belastungstabelle für Einfache Gleichstromkabel). Dr. Huberth Kath. Tables giving the maximum current permissible in continuous-current cables, according to the committee of the *Verband Deutscher Elektrotechniker*. 6000 w. Elektrotech Zeitschr—Nov. 17, 1904. No. 66858 B.

The Prevention of Induction in Cables for Weak Currents (Ueber die Vermeidung der Induktion bei Schwachstromkabeln). J. Schmidt. A description of the various methods of manufacturing and insulating cables, with especial reference to minimising the effects of induction. 3500 w. Zeitschr f Elektrotechnik—Dec. 11, 1904. No. 66873 D.

The Warning of Polyphase Underground Cables (Die Erwärmung Unterirdisch Verlegter Drehstromkabel). Dr. Richard Apt and Carl Mauritius. With numerous diagrams showing data and results of experiments. 3500 w. Elektrotech Zeitschr—Dec. 1, 1904. No. 66862 B.

Insulators.

Porcelain Insulators: Their Manufacture and Testing. H. W. Crozier. Brief description of methods of manufacture and testing. 2300 w. Cal Jour of Tech—Oct., 1904. No. 66420 C.

The Evolution of High-Tension Insulators. Reviews the paper of V. G. Converse read before the International Electrical Congress. Also editorial. Shows the requirements which practice has shown to be necessary for the pressures now used, and gives illustrated descrip-

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tions of types, showing developments. 4200 w. Elec Wld & Engr—Dec. 3, 1904. No. 66511.

Regulations.

The Home Office Draft Regulations for the Use of Electricity in Factories and Workshops. Frank Broadbent. A critical review of the Home Office regulations and those of the Board of Trade, which are compared. 4000 w. Elec Rev, Lond—Dec. 9, 1904. No. 66728 A.

South Wales.

Electric Power Distribution in South Wales. Map and illustrated description of a system supplying power to a large number of collieries and other works in the South Wales industrial district. 4000 w. Elect'n, Lond—Dec. 2, 1904. Serial. 1st part. No. 66632 A.

Sub-Stations.

The Lay-Out and Construction of a Modern Sub-Station. S. O. Swenson. An illustrated description of the design of the Ohio Street sub-station of the Chicago Edison Co. 2800 w. Am Elect'n—Dec., 1904. No. 66496.

The Substation of the Helena Light and Traction Company. Illustrated detailed description of a new substation made necessary by a fire. 2000 w. Jour of Elec—Dec., 1904. No. 66586 C.

Testing.

See Electrical Engineering, Measurement.

Three-Wire.

The Operation of a Three-Wire System with Battery (Ueber die Speisung eines Dreileiternetzes mit einer Batteriehälfte). F. Hohenemser. A brief description of a method of connecting a storage battery to a three-wire distribution system. 800 w. Elektrotech Zeitschr—Dec. 15, 1904. No. 66868 B.

Transformers.

The Computation of Transformers (Zur Berechnung von Transformatoren). Dr. Richard Hiecke. Deducing formulas and tables for the most efficient proportions of transformers, with practical applications. 3000 w. Zeitschr f Elektrotechnik—Nov. 13, 1904. No. 66869 D.

ELECTRO-CHEMISTRY.

Alternating.

Notes on Electrolysis with Alternating Currents (Beiträge zu Unseren Kenntnissen über die Elektrolyse mit Wechselströmen). A. Brochet and A. Petit. A long paper upon the methods by which alternating currents may be used for electrolytic purposes. 6000 w. Zeitschr f Elektrochemie—Dec. 2, 1904. No. 66876 D.

Aluminum.

Resistance and Polarization of Aluminum Anodes (Uebergangswiderstand und Polarisation an der Aluminuin-anode). Franz Fischer. A discussion of the conditions for the successful electro-deposition of aluminum. 4500 w. Zeitschr f Elektrochemie—Nov. 11, 1904. No. 66874 D.

Cells.

The Dynelectron. S. D. V. Burr. An illustrated description of the dynelectron cell, invented by James H. Reid, and its action, for producing electricity direct from heat. 1800 w. Ir Age—Dec. 8, 1904. No. 66542.

Copper.

Rapid Copper Plating Without Agitation or Warming (Schnell Kupferplastik ohne Umrührung und Erwarmung). Sergius v. Maximowitsch. The electrodes are placed horizontally, with the cathode beneath, the sulphate of copper sinking by gravity. 1000 w. Elektrochem Zeitschr—Nov., 1904. No. 66877 G.

Electric Furnaces.

The Electric Furnace: Its Origin, Transformations and Applications. Adolphe Minet. Defines and explains the apparatus, reviewing its history, and giving a bibliography of efforts which have been made to develop industries centering round the electric furnace. Discussion. 9500 w. Elec-Chem & Met—Dec., 1904. No. 66658 C.

Electro-Metallurgy.

A French Electro-Metallurgical Works. A short illustrated description of the La Praz installation, with remarks on other works in France. 2300 w. Min Rept—Dec. 1, 1904. No. 66499.

Electric Furnace Methods in Iron and Steel Manufacture in Comparison with the Ordinary Metallurgical Processes. Prof. B. Neumann. A review of this subject, with the conclusion that only for making special steels and high-per cent. ferro-alloys can the electric furnace be used economically. 2500 w. Elec-Chem Ind—Dec., 1904. No. 66608 C.

Electric Furnace Processes for Iron and Steel Manufacture. A summary of the report of the Commission appointed by the Canadian Government to investigate the different electrothermic processes for the smelting of iron ore and the making of steel in operation in Europe, calling attention to points that are new. 9000 w. Elec-Chem Ind—Dec., 1904. No. 66607 C.

Report of the Canadian Commission on Electrothermic Processes for the Production of Iron. Review of the report of a commission appointed to investigate the different electrothermic processes for the smelting of iron ores and the making of different classes of steel. 2500 w. Elec Rev, N Y—Dec. 3, 1904. No. 66480.

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The Production of Iron and Steel by Electric Processes (Die Herstellung von Eisen und Stahl auf Elektrischem Wege). Dr. Albert Neuburger. A very complete account of the practical applications thus far made of the electric furnace for smelting and refining iron and steel. Two articles. 8000 w. Glasers Annalen—Nov. 15, Dec. 1, 1904. No. 66826 each D.

The Production of Iron and Steel by the Electric Furnace. W. McClure. An illustrated article reviewing the various systems proposed, describing types of furnaces, and considering applications of the electrical system. 4300 w. Engng Rev—Dec., 1904. No. 66647 B.

Review.

Experimental Electrochemistry. N. Monroe Hopkins. This introduction to a series of papers gives a review of the historical work, with important classic researches and discoveries, and simple diagrams of the use of the electric current to electrolysis. Ills. 4400 w. Sci Am Sup—Dec. 3, 1904. Serial. 1st part. No. 66453.

Soda.

The Electrolytic Manufacture of Soda (Etude sur la Fabrication de la Soude Electrolytique). A description of the Heibling process, as conducted at Caudéran, near Bordeaux. 2000 w. L'Electrochimie—Nov., 1904. No. 66878 D.

ELECTRO-PHYSICS.

Air-Gaps.

The Magnetic Resistance of Air-Gaps. Translated from the *Electrotechnische Zeitschrift*. Results of experiments carried out by Dr. G. Benischke. 500 w. Elec Rev, Lond—Dec. 16, 1904. No. 66917 A.

Armatures.

Hydrodynamical and Electromagnetic Investigations Regarding the Magnetic-Flux Distribution in Toothed Armatures. Prof. H. S. Hele-Shaw, Alfred Hay, and P. H. Powell. Read before the Inst. of Elec Engrs. An illustrated account of investigations of air-gap reluctance, and reluctance of teeth in a slotted armature, with description of apparatus used, is given in the present number. 3500 w. Elec Engr, Lond—Nov. 25, 1904. Serial. 1st part. No. 66527 A.

On the Experimental Determination of the E. M. F. of Dispersion of Stray Field of an Armature Winding. C. F. Guilbert. Describes a method applying particularly to a revolving-field alternator, in which the armature is the external stator and the revolving field the internal rotor. 2500 w. Elec Wld & Engr—Dec. 3, 1904. No. 66510.

Dielectrics.

Experiments with Solid Dielectrics (Recherches sur les Diélectriques Solides). MM. V. Crémieu and L. Malclès. A discussion of experiments showing the existence of reactive charges in the interior of solid dielectrics. 1200 w. Comptes Rendus—Dec. 5, 1904. No. 66846 D.

The Dielectric Strength of Certain Specimens of Mica. Ernest Wilson and W. H. Wilson. Gives results of experiments, describing method of testing. 1000 w. Elect'n, Lond—Dec. 16, 1904. No. 66920 A.

Electric Sterilizer.

The Otto Electric Sterilizer. Translated from *La Nature*. Illustrates and describes an apparatus for the sterilization of water in private houses. 900 w. Sci Am Sup—Dec. 31, 1904. No. 66947.

Electromagnets.

The Predetermination of Plunger Electromagnets. Prof. Silvanus P. Thompson. Read before the Int. Elec. Cong. at St. Louis. A brief account of rules worked out by the author for the design of plunger electromagnets to fill required specifications. Ills. 5500 w. Elec Wld & Engr—Dec. 10, 1904. No. 66561.

Interrupter.

Electric Arc Interrupter (Lichtbogenunterbrecher). Dr. Hugo Mosler. Describing an arrangement of electric arcs in series for producing interruptions of high frequency for operating induction coils. 1200 w. Elektrotech Zeitschr—Dec. 1, 1904. No. 66863 B.

Magnets.

The Heating of Magnet Coils (Ueber Erwärmung von Magnetspulen). H. Lacroix. Deriving an approximate formula for computing the heating from the size and winding. 1800 w. Electrotech Zeitschr—Nov. 24, 1904. No. 66860 B.

Resistors.

Materials for Resistors. Francis A. J. Fitz Gerald. Explains the meaning of the term as used, and gives an experimental study, with conclusions. 5500 w. Elec-Chem Ind—Dec., 1904. No. 66609 C.

Striking Distance.

The Striking Distance in Gaseous Liquid and Solid Substances (Die Schlagweiten in Gasförmigen Flüssigen und Festen Korpern). Dr. W. Voege. Giving results of experiments showing the lengths of sparks at different voltages. 2500 w. Elektrotech Zeitschr—Dec. 8, 1904. No. 66865 B.

GENERATING STATIONS.

Alternator Regulation.

On the Theory of the Regulation of Alternators. C. F. Guilbert. Aims to show that a method suggested by the author two years ago leads in general, and especially in the case of an inductive load, to a much greater approximation than that demon-

strated by Messrs. Hobart and Punga, presented before Am. Inst. of Elec Engrs. 3300 w. Elec Wld & Engr—Dec. 17, 1904. No. 66712.

Combination Plants.

The Combination of Dust Destructors and Electricity Works Economically Considered. W. P. Adams. Abstract of a paper read before the Inst. of Elec Engrs. Gives a brief description of generally known types of destructors, discussing the principal aspect of combined plants, and the commercial results achieved. 4400 w. Elect'n, Lond—Dec. 16, 1904. Serial. 1st part. No. 66919 A.

The Combined Lighting and Heating Plants of the Columbus, Ohio, Public Service Company. Illustrates and describes a recently installed plant for heating by means of hot water, as an auxiliary service from an electric generating plant. 2200 w. Elec Wld & Engr—Dec. 3, 1904. No. 66506

Commutation.

Commutation and Straying (Ueber Kommutation und Streuung). F. Niethammer. A discussion of the conditions for sparkless commutation in continuous-current dynamos, and of the more precise determination of the stray field of induction motors. 2000 w. Zeitschr f Elektrotechnik—Nov. 20, 1904. No. 66870 D.

The Commutator. Norman G. Meade. Suggestions for refilling commutators. Ills. 1200 w. Mach, N Y—Dec., 1904. No. 66606 C.

Dynamos.

Comparative Designs for a 10-Kw. Dynamo. J. W. Burleigh. A short illustrated description of several types given for comparison. 800 w. Elec Rev, Lond—Dec. 9, 1904. No. 66726 A.

Efficiency of Compound-Wound, Direct-Current Generators. V. D. Moody. Describes the tests essential for accurate calculation of the efficiency, taking an actual case for demonstration. 2000 w. Elec Wld & Engr—Dec. 24, 1904. No. 66901.

Straightening Out a Dynamo. L. H. Pike. An account of a peculiar case in which the author was called to straighten out a factory dynamo. 1000 w. Power—Dec., 1904. No. 66601 C.

Gas Power.

See Mechanical Engineering, Combustion Motors.

Hydro-Electric.

A Central Station in the Tyrol. A. Steens. Illustrates and describes a water-power electrical generating plant of unusual interest at Zwolfmalgreien. 2200 w. Cent Sta—Dec., 1904. No. 66585.

Electricity from Water Power. A. A. Campbell Swinton. Read before the British Assn. An interesting review of hydro-electric engineering, with remarks on various installations. 3500 w. Sci Am Sup—Dec. 3, 1904. No. 66452.

The Bournillon Hydro-Electric Station (Usine Hydro-Electrique du Bournillon). Ch. Dantin. Describing the plant by which 3,750 horse power is developed from the Bourne, a tributary of the Isère, near Grenoble. The regulating apparatus is especially described. 2500 w. Génie Civil—Nov. 26, 1904. No. 66802 D.

The Installations of the Compagnie Vaudoise (Les Installations de la Compagnie Vaudoise). C. H. Perrin. A very complete account of the hydraulic generation and electrical transmission of 7000 horse power from lakes Joux and Orbe, in the canton of Vaud, Switzerland. Serial. Part I. 4000 w. Bull Tech de la Suisse Romande—Sept. 25, 1904. No. 66854 D.

The La Goule Hydroelectric Plant at Noirmont, Switzerland. Illustrated description of an interesting power plant in the mountains of Switzerland. It furnishes power for a large number of small motors used by watch makers; also furnishes light and power for French territory. 2200 w. Elec Rev, N Y—Dec. 10, 1904. No. 66589.

The Niagara Hydro-Electric Plant (Die Wasserkraft-Elektrizitätswerke am Niagara). K. Meyer. Describing especially the electrical machinery of the second power house of the Niagara Falls Power Co. 2500 w. Zeitschr d Ver Deutscher Ing—Nov. 19, 1904. No. 66809 D.

The Reservoirs and Electric Service of Solingen (Barrages-Reservoirs et Services Electriques de la Ville de Solingen). A. Bidault des Chaumes. With illustrations of the dams, artificial reservoirs and hydro-electric station near Solingen, in Rhenish Prussia. 3000 w. 1 plate. Génie Civil—Dec. 3, 1904. No. 66803 D.

Isolated Plant.

The Engineering Plant at the New Savoy Hotel. Sydney F. Walker. An illustrated article describing in detail the boiler plant, electricity generating plant, lighting service, cold-storage and ice-making plant, ventilating and heating system, elevator system, etc. 3000 w. Engng Rev—Dec., 1904. No. 66646 B.

The Power Plant of the Oliver Building, Boston. Howard S. Knowlton. Brief description of an isolated plant for supplying heat, light and power. 1000 w. Eng Rec—Dec. 17, 1904. No. 66685.

Oil.

Oil for Transformers, Switches, etc. E. Kilburn Scott. On the treatment of oil for transformers, and its proper use. 700 w. Elec Rev, Lond—Dec. 2, 1904. No. 66631 A.

We supply copies of these articles. See page 876.

Operation.

Electrical Pointers. W. H. Wakeman. Points concerning the operation of generators and motors, with diagrams. 2000 w. Power—Dec., 1904. No. 66597 C.

Parallel Driving.

See Mechanical Engineering, Steam Engineering.

South Africa.

Pietermaritzburg (Natal) Electric Lighting and Tramways. Brief, illustrated description of the plant. All the cables are laid underground. Maps. 3000 w. Elec Rev, Lond—Dec. 9, 1904. No. 66727 A.

Storage Batteries.

Limitations to the Use of Storage Batteries—An English Engineer's Views. H. M. Hobart, in *Technics*. A discussion of the deterioration and cost of storage batteries, their efficiency, etc. 2400 w. Sci Am Sup—Dec. 24, 1904. No. 66902.

LIGHTING.

Bridge Lighting.

The Illumination of the Williamsburg Bridge, New York City. Illustrates and describes the manner in which the lighting work has been carried out. 1500 w. Elec Wld & Engr—Dec. 24, 1904. No. 66798.

Signal Lamps.

Electric Signal Lighting on the Lancashire and Yorkshire Railway. Illustrates and describes the method employed for fitting up their electric signal lamps. 1500 w. Elec Rev, Lond—Dec. 2, 1904. No. 66628 A.

MEASUREMENT.

Accumulators.

Testing Instruments for Accumulators. H. M. Wyatt. Considers hydrometers and voltmeters and the proper way of using them. 2200 w. Autocar—Dec. 17, 1904. No. 66913 A.

Alternate-Current Instruments.

The Use of Iron in Alternate-Current Instruments. Dr. W. E. Sumpner. Abridged address before the Inst. of Elec. Engrs., Birmingham. Considers the reasons for the unsatisfactory results obtained with instruments for alternate-current measurements and the reasons and future prospects. 4000 w. Elect'n. Lond—Nov. 25, 1904. Serial. 1st part. No. 66532 A.

Faults.

The Measurement of an Insulation Fault Between a Cable and the Earth (Mesure d'un Défaut d'Isolement entre un Cable et la Terre). J. Vinson. Brief description of method of locating a fault in a distribution system while under charge. 800 w. Revue Technique—Nov. 25, 1905. No. 66834 D.

Magnetic Testing.

A Method of Measuring Magnetomotive Forces. Rudolf Goldschmidt. Illustrated description of a method of measuring the "magnetic potential drop," which is easy to manipulate, and requires a minimum of special apparatus or fine adjustment. 1200 w. Elect'n, Lond—Nov. 25, 1904. No. 66531 A.

Studies in Magnetic Testing. G. F. C. Searle. Read before the Inst. of Elec. Engrs. (Abridged). Describes investigations made by the author on the effects of magnetic treatment. A critical examination of the use of the ballistic method in magnetic tests of transformer iron. 4000 w. Elect'n, Lond—Dec. 9, 1904. Serial. 1st part. No. 66729 A.

Meter.

Notice of Test and Approval by the Testing Office (Bekanntmachung über Prüfungen und Beglaubigungen durch die Elektrischen Prüfämter). A report of the Reichsanstalt upon the testing of the O'Kennan continuous-current meter. 1800 w. Elektrotech Zeitschr—Nov. 24, 1904. No. 66859 B.

Power Factor.

The Power Factor Indicator. Harry W. Richardson. Describes the theory of action of the power factor indicator, explaining its action by the aid of mathematics. 1600 w. Elec Wld & Engr—Dec. 29, 1904. No. 66900.

Testing.

Special Methods for Locating Faults on Electric Cables. Henry W. Fisher. Illustrates and describes methods more or less connected with the Murray & Varley "Loop Tests," and emphasizes the importance of determining accurately the resistance of subsidiary resistances in the circuit of a faulty cable under localization test. 1600 w. Elec Wld & Engr—Dec. 17, 1904. No. 66711.

The Testing Equipment of a Common Battery Central Office. A. Dallam O'Brien. Discusses the principal troubles that arise on substation lines, and the methods used by the wire chief to locate them and to arrange for their removal. Diagrams. 3200 w. Am Elect'n—Dec., 1904. No. 66497.

Torque.

Electromagnetic Torque. A. S. McAllister. Describes somewhat unusual conditions for obtaining torque. Diagrams. 700 w. Elec Wld & Engr—Dec. 3, 1904. No. 66509.

MOTORS.

Commutator Motors.

Alternating-Current Commutator Motors (Wechselstrom-Kommutatormotoren). Dr. F. Niethammer. A general discussion of recent single-phase motors.

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2000 w. Zeitschr f Elektrotechnik—Dec. 4, 1904. No. 66872 D.

Commutation in Alternating-Current Motors at Starting. Marius Latour. Presents some precise considerations relating to the special conditions of commutation at starting. 1200 w. Elec Wld & Engr—Dec. 3, 1904. No. 66507.

Multiple-Voltage.

Multiple Voltage Control of Motors. Norman Gardner Meade. An illustrated description of the Bullock system, stating its advantages, and remarks on the installation of the plant. 1500 w. Power—Dec., 1904. No. 66595 C.

Rheostat.

A New Form of Liquid Rheostat for Starting Electric Motors. States the advantages and disadvantages of liquid rheostats and gives an illustrated description of a new type invented by Mr. Woolliscroft. 1000 w. Sci Am—Dec. 3, 1904. No. 66450.

Variable Speed.

Standardizing Variable Speed Motors. W. H. Powell. Read before the Nat. Machine Tool Bldrs. Assn. Shows how the output for a given size motor frame and armature core varies for the different systems of speed control, and also when operated at different amounts of speed variation. 900 w. Ir Trd Rev—Dec. 1, 1904. No. 66429.

TRANSMISSION.

Lightning.

Lightning Protection. J. V. E. Titus. Read before the Colorado Elec. Lgt., Power & Ry. Assn. Discusses points to be considered in installing lightning arresters. 1800 w. Elec Rev, N Y—Dec. 24, 1904. No. 66778.

Power Transmission.

The Maximum Distance to Which Power Can Be Economically Transmitted. Ralph D. Mershon. States the assumptions on which the reasoning is based, and discusses the cost of line conductors as limiting the distance. 5500 w. Trans Am Inst of Elec Engrs—Dec. 23, 1904. No. 66651 D.

Shawinigan Falls.

The Electric Power Development at Shawinigan Falls. A description, with illustrations of the plant for the longest electrical transmission line in operation in Canada, which delivers current over ninety miles. 3000 w. Can Elec News—Dec., 1904. No. 66717.

MISCELLANY.

Address.

Some Difficulties in Getting On. J. Swinburne. Address delivered to the students of the Inst. of Elec. Engrs. 6000 w. Elect'n, Lond—Nov. 18, 1904. No. 66617 A.

Exhibit.

The Novel Features of the Westinghouse Exhibit at the Louisiana Purchase Exposition. Edgar S. Downs. Reviews the striking features of the exhibits. 3500 w. Elec Rev, N. Y.—Dec. 24, 1904. No. 66779.

Fire Hazard.

The Electrical Fire Hazard. C. J. H. Woodbury. Abstract of an address before the Brooklyn Inst. of Arts & Sciences. A discussion of the underwriter's rules. 1500 w. Elec Rev, N. Y.—Dec. 10, 1904. No. 66591.

Law.

The Law Relating to the Escape of Electricity. W. Valentine Ball. Discusses briefly the principles that appear to have been adopted by the courts in both England and America. 4400 w. Elec Wld & Engr—Dec. 17, 1904. No. 66713.

INDUSTRIAL ECONOMY

British Trade.

The Systematic Promotion of British Trade. Ben H. Morgan. Discusses the relations of the state and trade, the control of shipping monopolies, consular service, &c., &c. Discussion. 8800 w. Jour Soc of Arts—Nov. 25, 1904. No. 66521 A.

Coal Production.

The Coal Production of the World (Die Steinkohlenvorräte der Erde). Oskar Simmersbach. A classified statement of the coal production of the various important producing countries of the world, showing the rate of increase. 5000 w. Stahl u Eisen—Dec. 1, 1904. No. 66887 D.

Exports.

Six Years of British and American Electrical Export Statistics. W. Pollard Digby. Gives the exports to certain trade zones, considering the tendencies exhibited. 2000 w. Elec Rev, Lond—Nov. 25, 1904. No. 66529 A.

Locomotive Trade.

The British and American Locomotive Export Trade. W. Pollard Digby. A study of American and English returns, showing that British locomotive builders hold a high repute. 3000 w. Engr, Lond—Dec. 16, 1904. No. 66924 A.

We supply copies of these articles. See page 876.

Patents.

The Patent Laws. Charles Denton Abel. Reviews the systems in the different countries, discussing their defects, and proposing remedies. Appendices and discussion. 14000 w. Jour Soc of Arts—Dec. 16, 1904. No. 66910 A.

Works Management.

Machine Shop Management. Oscar E. Perrigo. Deals with the management of a model machine shop in a general way. 2800 w. Ir Trd Rev—Dec. 1, 1904. No. 66430.

The Organization and Methods of a Modern Industrial Works. J. Wilmer Henszey. Describes the management of the Baldwin Locomotive Works, in Philadelphia, which employs about 15,500 men. 3700 w. Jour Fr Inst—Dec., 1904. No. 66669 D.

MARINE AND NAVAL ENGINEERING

Battleships.

H. M. First-Class Battleship Triumph. Engravings and description of the vessel and its equipment. 1200 w. Engr, Lond—Nov. 25, 1904. No. 66537 A.

The Battleship Deutschland. Describes this first ship of a new class, commenting on the improvements introduced. 2000 w. Engr, Lond—Nov. 25, 1904. No. 66538 A.

The Italian Battleship "Regina Margherita." Two-page plate with detailed description of this vessel and its equipment. 2200 w. Engng—Nov. 25, 1904. No. 66534 A.

The Latest British Battleship. Illustrated description of the first-class battleship Dominion. 1200 w. Naut Gaz—Dec. 15, 1904. No. 66673.

U. S. Battleship Ohio. Lieut. J. F. Babcock. Illustrated description of the vessel, with report of official trial performance. 10700 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66754 H.

Breakdowns.

Microscopic Observations on Naval Accidents. Thomas Andrews. A report of the writer's researches into some of the microscopic examinations of fractured portions of marine machinery. Fully illustrated. 3300 w. Engng—Dec. 2, 1904. Serial. 1st part. No. 66634 A.

Cofferdam.

Proposed Cofferdam for Raising the Battleship "Maine." An illustrated explanation of the proposed method of raising this vessel and freeing Havana harbor of the obstruction. 2500 w. Eng News—Dec. 8, 1904. No. 66554.

Cranes.

The Hydraulic Crane System on the Steamer Barbarossa (Die Hydraulische Krananlage auf dem Dampfer Barbarossa des Norddeutschen Lloyds). W. Gentsch. With illustrations showing the pumps, accumulators and general arrangements. 1000 w. Zeitschr d Ver Deutscher Ing—Nov. 12, 1904. No. 66807 D.

Cruiser.

United States Armored Cruiser Colorado. E. H. Scribner. Illustrated description of vessel, with report of the official trial. 6000 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66758 H.

Floating Dock.

A New Offshore Floating Dock. Illustrated description of a new dock for the port of Hamburg. 700 w. Sci Am Sup—Dec. 31, 1904. No. 66946.

Freeboard.

Freeboard. Gives details connected with its origin and subsequent official application in Great Britain as one of the means to prevent overloading. 4500 w. Marine Engng—Dec., 1904. No. 66549 C.

Freight Handling.

Handling of Freight in British Ports. An illustrated article on the immense amount of freight entering these ports and the modern facilities for dealing with it expeditiously. 3500 w. Marine Rev—Dec. 1, 1904. No. 66484.

Lifeboat.

Unsinkable Lifeboat. Illustrated description of the Englehardt unsinkable lifeboat. 800 w. U. S. Cons Repts—Nov., 1904. No. 66740 D.

Motor Boats.

High-Speed Motor Boats (Les Canots Automobiles à Grande Vitesse). A. Tellier fils. Details of speed trials of a number of boats propelled by petrol motors at speeds up to 40 kilometres per hour. 4000 w. 1 plate. Mem Soc Ing Civ de France—Oct., 1904. No. 66851 G.

Naval Conflicts.

Naval Aspects of the War in the Far East. Archibald S. Hurd. Discusses the methods adopted by Japan and Russia, and the lessons to be learned. 8500 w. Cassier's Mag—Dec., 1904. No. 66459 B.

Navy Yards.

The Character of the Power Plants in the U. S. Navy Yards. A review of the report of civilian engineers retained to make an examination of the plants. 2500 w. Eng Rec—Dec. 3, 1904. No. 66475.

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River Boats.

Steam Navigation on Western Rivers. An illustrated article describing the early boats used on the Mississippi and other Western rivers. 2300 w. Naut Gaz—Dec. 1, 1904. No. 66483.

Speeds.

The Criterion of High Speeds of Ships (Criterium des Navires à Grandes Vitesses). Vice Admiral Fournier. Showing that the resistance of the water at increasingly high speeds tends to become proportional to the square of the speed. 1500 w. Comptes Rendus—Dec. 5, 1904. No. 66844 D.

The Influence of Depth of Water on the Speed of Torpedo Boats (Versuche zur Ermittlung des Einflusses der Wassertiefe auf die Geschwindigkeit der Torpedoboote). H. Paulus. A discussion of trials of torpedo boats in deep and shallow water, with curves showing the results. 5000 w. Zeitschr d Ver Deutscher Ing—Dec. 10, 1904. No. 66815 D.

Steamers.

Paddle Steamers (Raddampfer). W. Kaemmerer. A description of the hull and engines of the paddle steamers built at Kiel for use in connection with the service of the Anatolian railway. 1500 w. Zeitschr d Ver Deutscher Ing—Nov. 12, 1904. No. 66806 D.

The New Thames Passenger Steamers. An account of the steps taken to establish a passenger steamboat service on the Thames River, and an illustrated description of the recommended design, with information concerning cost. 1700 w. Engr, Lond—Dec. 2, 1904. No. 66640 A.

Structural Details.

Experiments on Some Structural Details. An illustrated account of deviations from normal arrangements, tested to destruction under the authority of Lloyd's, to determine the actual efficiencies of some of the proposals made to effect economies or to obtain more space. 1400 w. Engr, Lond—Nov. 25, 1904. No. 66539 A.

Torpedo Boats.

Contract Trial of Torpedo Boat No. 27, the Blakely. Description of vessel and its equipment, with report of trial. 4800 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66756 H.

Torpedoes.

The Discovery and Removal of Contact Mines (De la Recherche et du Dragage des Torpilles Vigilantes). M. Dibos. An account of modern floating contact mines used for harbor defence in time of war, and the methods of dragging for their removal. 3500 w. Mem Soc Ing Civ de France—Oct., 1904. No. 66852 G.

Turbines.

Reports on Turbine Installations. Reports of the installations on the steam yachts Lorena and Tarantula, and steamer Turbinia. Ills. 6700 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66757 H.

Warships.

A United States Warship on Trial. An account of the government speed trial of the Pennsylvania, by a witness, with general remarks. 2000 w. Sci Am—Dec. 3, 1904. No. 66448.

MECHANICAL ENGINEERING

AUTOMOBILES.

Air Cooling.

Frayer-Miller Air-Cooled Car. Illustrated detailed description. 1200 w. Automobile—Dec. 24, 1904. No. 66791.

Automobile Battery.

The Schneider-Canet du Bogage Automobile Battery of Quick-Firing Howitzers. Illustrations, with brief description. 600 w. Engng—Nov. 25, 1904. No. 66533 A.

Carbureter.

New Form of Automatic Carbureter. Illustrates and describes an interesting new carbureter brought out by Grouvelle and Arquembourg. 1800 w. Automobile—Dec. 24, 1904. No. 66790.

The Claudel Kerosene Carbureter. Explains the designer's theory of the gasification of heavy oils, and its practical application to automobile motors. 2400 w. Automobile—Dec. 10, 1904. No. 66579.

Electric Truck.

An Electric Truck Test. W. S. Timmis. Reports a test made of three electric trucks, extending over a period of four months, comparing cost with horse-drawn trucks. 1500 w. Am Mach—Vol. 27, No. 51. No. 66744.

Exhibition.

Motor Cars in Paris. Survey of the progress in the motor-car industry, as judged by the exhibits at the Paris Show. 3000 w. Engr, Lond—Dec. 16, 1904. Serial. 1st part. No. 66926 A.

Paris Salon, 1904. Brief illustrated descriptions of some of the exhibits, and remarks on the interesting features of the

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exhibition. 3500 w. Auto Jour—Dec. 17, 1904. Serial. 1st part. No. 66912 A.

Hub-Motor.

Practical Test of Hub-Motor Truck. An illustrated account of a demonstration made by the Holson electric truck on a steep hill in New York, with description of the steering and wheel construction. 2200 w. Automobile—Dec. 17, 1904. No. 66697.

Itala.

The 24-H. P. Itala Car. Illustrated description of a new car embodying features conducing to silent and smooth running, and ready accessibility for adjustment. 700 w. Autocar—Dec. 3, 1904. No. 66621 A.

Light Cars.

The Progress of the Light Motor Car. From a paper by W. W. Beaumont, read before the Automobile Club. Discusses questions affecting the design and construction of motor cars and motors. 4000 w. Engr, Lond—Dec. 9, 1904. No. 66736 A.

Omnibus Service.

The Great Western Motor Omnibus Services. W. B. Paley. An account of this system as used by the British railroad named. 2500 w. R R Gaz—Vol. XXXVII, No. 28. No. 66768.

Rolls-Royce.

The "Rolls-Royce" Petrol Cars. An illustrated description of a new car of British construction, to be exhibited at the Paris Salon. 1000 w. Auto Jour—Dec. 3, 1904. Serial. 1st part. No. 66623 A.

Simplex.

Simplex 30-H. P. Touring Car. Illustrated detailed description of new cars built in design and construction like the 75-h. p. S & M. Simplex special racing machine. 1500 w. Automobile—Dec. 10, 1904. No. 66578.

Stanley Show.

The Stanley Show. Illustrates and describes the tricars and other vehicles exhibited. 2800 w. Auto Jour—Nov. 26, 1904. No. 66524 A.

Steam Car.

New Grout Steam Car. Illustrates and describes the latest model of Grout Brothers of Orange, Mass. 900 w. Automobile—Dec. 24, 1904. No. 66792.

Wheels.

Motor Car Wheels. E. W. Walford. Discusses briefly the merits and demerits of each type. Ills. 1200 w. Autocar—Dec. 10, 1904. No. 66721 A.

White.

The New 15-H. P. White Steam Car. Illustrated description of a new car, noting its improvements. 2000 w. Autocar—Dec. 3, 1904. No. 66622 A.

COMBUSTION MOTORS.

Alcohol.

Industrial Alcohol (Alcool Industriel). Octave Rochat. A study of the applications of alcohol as a source of energy in internal-combustion motors. Three articles. 7500 w. Bull Tech de la Suisse Romande—Sept. 25, Oct. 10, 25, 1904. No. 66855 each D.

Diesel.

Diesel Engine at Rothesay. Illustrations, with brief description of the engine at work at the power-station of the Rothesay Tramways. 1400 w. Tram & Ry Wld—Dec. 8, 1904. No. 66771 B.

Notes on the Diesel Motor (Mitteilungen über den Dieselmotor). Illustrating very fully the later improved form of Diesel motor as constructed by Sulzer Bros., of Winterthur, Switzerland. A thermal efficiency of 35 per cent. on the brake horse power is attained. 3000 w. Schweiz Bauzeitung—Nov. 26, 1904. No. 66847 B.

Gas Engines.

Gas Engines for Central Stations. Hugh Campbell. Read before the Leeds Local Sec. of the Inst. of Elec. Engrs. Describes some recent plants where gas engines have been installed, showing the great improvement in economy since the first installation, and giving information of value. 3500 w. Engng—Dec. 16, 1904. No. 66923 A.

Gas Engines in Power Plants. William T. Magruder. Read before the Mech., Elec., & Steam Engrs. at the Canton, O., meeting. Discusses the advantages of the use of gas engines in power plants, and why they are not more frequently used. 2500 w. Ir Trd Rev—Dec. 8, 1904. No. 66547.

Power Generation with Large Gas Engines (Betriebserfahrungen mit Grossgasmotoren). H. Strack. Discussing especially the use of gas power in iron works, with illustrations of large gas-blowing engines. 6000 w. 3 plates. Stahl u Eisen—Nov. 15, 1904. No. 66884 D.

Recent Developments in Gas Engines. An illustrated article referring particularly to the large German and other European designs. 2400 w. Ir & Steel Mag—Dec., 1904. No. 66660 D.

The Gas Engine in Iron and Steel Works. J. H. Hamilton. Read at meeting of the Staffordshire Iron and Steel Inst. Considers the advantages of the internal combustion engine, discussing its efficiency, economy, etc. 3700 w. Ir & Steel Trds Jour—Dec. 3, 1904. No. 66633 A.

The Regulation of Gas Engines. Dr. Charles E. Lucke. Concludes that regulation of angular velocity can be adjusted in gas engines to as small limits as in steam engines; also considers regulation

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of steam. General discussion. 8700 w. Pro N Y R R Club—Nov. 18, 1904. No. 66674.

Gas Power.

The Tunis Central Station and the Pierson Gasogene. Emile Guarini. Illustrates and describes a station representing the most advanced engineering methods that have been developed in Europe for the driving of dynamos by gas engines that are in turn operated from gas generators especially designed for the purpose. 2200 w. Jour of Elec—Dec., 1904. No. 06587 C.

Gas Producers.

A Study of the Gas Producer (Untersuchungen an Gaserzeugern). Karl Wendt. Data and results of a series of experiments upon producer gas for motive power, using a specially designed experimental producer. 5000 w. Zeitschr d Ver Deutscher Ing—Nov. 26, 1904. No. 66811 D.

Suction Gas Producers. B. A. Sinn. An illustrated description of this type of apparatus which does away with the gasholder, explaining the principles involved and the operation and care necessary. 3400 w. Power—Dec., 1904. No. 66598 C.

Gas Turbines

An Experimental Gas Turbine. Dr. Alfred Gradenwitz. An illustrated description showing the principle of the hot-air turbine invented by Dr. F. Stolze. 1500 w. Mach, N Y—Dec., 1904. No. 66603 C.

The Coming of the Gas Turbine. E. Kilburn Scott. A discussion of the chances of the gas turbine as a prime mover, with brief reference to the recent paper by R. M. Neilson. 1200 w. Elec Rev, Lond—Nov. 25, 1904. No. 66528 A.

Heat Motor.

A New Type of Heat Motor (Sur un Nouveau Genre d'Appareils Thermiques). H. Royer. A mathematical investigation of the application of the jet principle to combustion motors for the production of fluid pressure for action upon a turbine or similar machine. Serial, Part I. 7500 w. Revue de Mécanique—Nov. 30, 1904. No. 66856 E + F.

Ignition.

Electric Ignition for Combustion Motors (Die Elektrische Zündung bei Explosionsmotoren). Josef Löwy. A discussion of the best method of producing and timing the igniting spark for internal-combustion motors. 3000 w. Zeitschr f Elektrotechnik—Nov. 27, 1904. No. 66871 D.

Ignition as Applied to Internal Combustion Engines. Sir Oliver Lodge. Abstract of a lecture delivered before the members of the Automobile & Cycle Engrs'. Inst. Discusses briefly the critical point of ignition and types of ignition. 1700 w. Autocar—Dec. 10, 1904. No. 66722 A.

Petrol Engine.

The Craig-Dörwald 12-Cylinder Petrol Engine. Illustrated description of an engine in which compactness is the chief object aimed at. 1000 w. Auto Jour—Dec. 3, 1904. No. 66624 A.

HEATING AND COOLING.

Public Buildings.

The Warming of Public Buildings by the Warm-Air System Considered from a Hygienic Point of View. H. H. Grundy. Read before the British Inst. of Heating & Ven. Engrs. Discusses the necessity of introducing an ample supply of fresh air, and shows how an apparatus can be installed to introduce air from the outside of the building, the arrangement, operation, etc. 4000 w. Dom Engng—Dec. 24, 1904. No. 66789.

Refrigeration.

Comparing Refrigerating Systems. Relative value of compression refrigerating machines operated with ammonia, carbon dioxide and sulphur dioxide and wet and dry air coolers. Paper by Richard Stetefeld, with synopsis of discussion. Diagrams. 8200 w. Ice & Refrig—Dec., 1904. No. 66505 C.

Condensed Steam for Ice Making. William W. Stickney. Observations on the proper care of distilled water supply and how to overcome some of the most serious difficulties met. 1800 w. Ice & Refrig—Dec., 1904. No. 66504 C.

HYDRAULICS.

Cranes.

See Marine and Naval Engineering.

Current Wheels.

Current Wheels: Their Use in Lifting Water for Irrigation. From Bulletin 146 of the U. S. Dept. of Agri. An illustrated article on the theory of power in current wheels, their efficiency, practical operations, etc., describing wheels in actual use. 2000 w. Sci Am Sup—Dec. 3, 1904. Serial. 1st part. No. 66456.

Holyoke.

The Water Power at Holyoke. Albert F. Sickman. An interesting review of the history of the water power developed, the various dams, and their troubles, cost, etc. 5000 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66747 F.

Hydro-Electric Stations.

See Electrical Engineering, Generating Stations.

Hydraulic Packings.

Notes on Hydraulic Packings and Stuffing-Box Design. Ulrich Peters. Describes

several constructions of hydraulic cylinder and plunger packings and their practical applications, and gives hints for selecting and designing satisfactory packing for parts moving under hydraulic pressure. 1500 w. Ir Age—Dec. 15, 1904. No. 66661.

Pipes.

The Flexure of the Walls of Pipes of Large Diameter (Flexion des Parois dans les Tuyaux de Conduites de Grand Diametre). C. Birault. An exhaustive discussion of the deflections and distortions of large pipes for conveying water for hydraulic power. 10,000 w. 1 plate. Mem Soc Ing Civ de France—Oct., 1904. No. 66849 G.

Plumbing.

Sanitary Plumbing and the Plumbing Laws. J. Pickering Putnam. Read before the Boston Soc of Arts. An examination of the plumbing laws, with suggestions for amendments. Ills. 3800 w. Am Archt —Dec. 24, 1904. Serial. 1st part. No. 66788.

Pumping.

A Study of Pumping Machinery (Versuche an Wasserhaltungen). Prof. Baum and Dr. H. Hoffmann. A comparison of the performances of steam, hydraulic, and electrical mine pumping plants in actual service, with data and results of tests. Serial. Part I. 5000 w. Zeitschr d Ver Deutscher Ing—Dec. 3, 1904. No. 66813 D.

Pumping Plant for the New South Dock, Cardiff. Illustrated description of a large plant. 1000 w. Engr, Lond—Dec. 9, 1904. No. 66734 A.

The Development of Power Pumping Machinery. W. M. Barr. Modern methods of overcoming high lifts and heavy service, with latest improved forms of pumping machinery. 2500 w. Engineering Magazine—Jan., 1905. No. 66895 B.

Pumps.

Pumps in Central Stations. W. T. Edwards. Suggestions for the care and management of these pumps; the power required, size, etc., are also considered. 1500 w. Am Elect'n—Dec., 1904. No. 66498.

Valves.

The Action of Pump Valves (Fonctionnement des Soupapes de Pompes). M. Lecuir. A translation of the paper of Berg upon experiments on spring-loaded pump valves. Serial. Part I. 7000 w. Revue de Mécanique—Nov. 30, 1904. No. 66857 E + F.

Water Power.

The Commercial Development of Water Power. Alton D. Adams. Discusses the successful development of water power from a financial point of view, illustrating by cases from actual practice. 3000 w. Cassier's Mag—Dec., 1904. No. 66461 B.

MACHINE WORKS AND FOUNDRIES.

Balancing.

Notes Upon Balancing High-Speed Machinery. Explains the "critical speed" of bodies rotating with high velocity, and other points connected with the subject of balancing. Ills. 1500 w. Mach, N Y—Dec., 1904. No. 66604 C.

Blowers.

Fan and Positive Pressure Blower Tests. W. H. M'Faddon. Read before the Pittsburg Found. Assn. Gives history of tests made and conclusions reached. 4300 w. Ir Age—Dec. 8, 1904. No. 66543.

Boring.

A Boring-Mill Job. An illustrated account of a specially fitted up boring and turning mill which enabled the time for finishing a gas-engine fly-wheel to be reduced from 2 hrs. 20 min. to 45 min., and the work was better done. 1000 w. Am Mach—Vol. 27, No. 49. No. 66545.

Castings.

Casting Spouts and Tuyere-Boxes. Hiram W. Hixon. Drawings and description of methods for casting spouts for copper blast-furnaces, and tuyere-boxes for copper converters, of converter copper. 400 w. Eng & Min Jour—Dec. 22, 1904. No. 66762.

Chain.

Weldless Chain (Nahtlose Ketten). O. Klatte. Describing processes for making weldless chain by rolling and forming machinery. Two articles. 4000 w. Stahl u Eisen—Nov. 15, Dec. 1, 1904. No. 66885 each D.

Core Sand.

The Use of Old Core Sand. Charles A Smith. An explanation of the writer's practice of using old core sand in new core mixtures. 800 w. Foundry—Dec., 1904. No. 66675.

Dust Collecting.

The Exhaust System of Dust Collecting as Applied to Grinding Machinery, Etc. Vernon I. Norbury Williams. An illustrated article presenting the merits of this system. 2000 w. Ir & Coal Trds Rev—Dec. 2, 1904. No. 66643 A.

Electric Driving.

Motor Driving of Machine Tools. Dexter S. Kimball. Discusses the advantages and disadvantages of group driving compared to individual application of the motor, and the speed range to be given by the motor and the method of obtaining the same. 2800 w. Sib Jour of Engng—Dec., 1904. No. 66657 C.

The Advantages of the Electric Drive. D. N. Dunlop. States the advantages claimed, discussing the economy and increase of production. Ills. 4000 w. Ir &

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Coal Trds Rev—Dec. 16, 1904. No. 66930 A.

Factory.

The Edward R. Ladew Leather Belting Factory. Brief, illustrated description of this factory at Glen Cove, L. I., and the methods of manufacture. 1400 w. Am Mach—Vol. 27. No. 51. No. 66743.

Foundations.

Foundations and Foundation Drawings. A. D. Williams. Directions for preparing foundations for heavy machinery. 1200 w. Am Mach—Vol. 27, No. 51. No. 66746.

Foundry Fuels.

Coal and Coke for Foundry Use. Prof. Bradley Stoughton. Read before the N. Y. Found. Foremen's Assn. An explanation of the origin and manufacture of these fuels. 1200 w. Foundry—Dec., 1904. No. 66079.

Foundry.

System in the Foundry. P. R. Ramp. Suggestions for daily reports useful in the successful management of the foundry. 1800 w. Foundry—Dec., 1904. No. 66680.

Gauges.

Variation in Size of Work Due to Type of Gauge. George Schlesinger. A summary of experiments made in connection with a limit gauge system. Ills. 1000 w. Am Mach—Vol. 27, No. 48. No. 66413

Lathe.

The Latest Hendey-Norton Lathe. Illustrated description of a lathe designed with the object of increasing the producing capacity. 1200 w. Ir Age—Dec. 29, 1904. No. 66935.

The New Prentice 18-Inch Lathe. Illustrated description of a lathe designed especially for use with the new tool steels. 1800 w. Ir Age—Dec. 1, 1904. No. 66467.

Malleable Work.

Loss in Malleable Foundry. R. F. Flinterman. Read at the A. F. A. convention. Gives in detail the methods employed for determining the character of the loss due to the chemical changes of various kinds. 1200 w. Foundry—Dec., 1904. No. 66677.

Molding.

Molding and Core Making for a Long Steam Feed Cylinder. R. H. Palmer. Illustrated detailed description. 800 w. Am Mach—Vol. 27, No. 48. No. 66414.

Sweeping a Mold for a Split Fly-Wheel. R. H. Palmer. Illustrated detailed description of method. 1600 w. Am Mach—Vol. 27, No. 52. No. 66933.

New Works.

Messrs. Bruce Peebles & Co.'s New Works at East Pilton, Edinburgh. An illustrated detailed description of a plant for the manufacture of electrical machinery and its general arrangement. 4000 w. Elec Engr, Lond—Nov. 25, 1904. No. 66526 A.

Planers.

Modern Planers. Brief, illustrated descriptions of various types, with general remarks. 4500 w. Cassier's Mag—Dec., 1904. No. 66460 B.

Planing.

Planing Cycloidal Curves. Howard A. Coombs. Illustrates and describes machines for planing the cycloidal surfaces of the "revolvers" of blowers, rotary pumps, etc., which partake of some of the characteristics of both planers and gear cutters. 1200 w. Am Mach—Vol. 27, No. 52. No. 66934.

Power Plant.

Power Plant at the Works of the Power and Mining Machinery Co. Illustrated description of the power plant of manufacturing works near Milwaukee, Wis. 2000 w. Engr, U S A—Dec. 15, 1904. No. 66695 C.

Records.

Pattern Loan Records. R. W. MacDowell. Describes a simple system of pattern records. 1800 w. Foundry—Dec., 1904. No. 66676.

Reversing-Gear.

Coil Clutch Reversing-Gear for Rolling Mills. Illustrated description of a very large reversing-clutch supplied to a copper-rolling mill in France. 1000 w. Engng—Dec. 16, 1904. No. 66922 A.

Rusty Nuts.

Removing Rusty Nuts and Bolts. Walter J. May. Suggestions. 900 w. Prac Engr—Dec. 2, 1904. No. 66626 A.

Shops.

Plant of the Locomotive & Machine Company of Montreal. Brief description, with illustration and plans. 700 w. Am Engr & R R Jour—Dec., 1904. No. 66440 C.

Messrs. Everett, Edgcumbe, and Co.'s London Works and Some of Their Specialties. Brief, illustrated description of the works and of some of the electrical instruments made by them. 3500 w. Elec Engr, Lond—Dec. 16, 1904. No. 66915 A.

The Works of the Power and Mining Machinery Co. Illustrated description of shops at Cudahy, Wis., designed to embody all tools and arrangements tending to secure economy in manufacture of its special products. 4000 w. Eng Rec—Dec. 3, 1904. No. 66473.

Shop Transport.

Mechanical Transport in the Modern Machine Shop. F. A. Waldron. A discussion of the economies effected by the use

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of cranes, hoists, and other conveying devices for minimizing the non-productive labor of the machinist. 4000 w. Engineering Magazine—Jan., 1905. No. 66889 B.

Slag.

Slag in Castings. William Leary. Discusses the causes and remedies for slag in castings and for kishy and gassy iron. 1500 w. Foundry—Dec., 1904. No. 66681.

Works Management.

See Industrial Economy.

MATERIALS OF CONSTRUCTION.

Alloys.

Invar and Its Applications. Ch. Ed. Guillaume. Describes results obtained by this curious alloy, giving an account of its discovery, the applications made, and information of interest. Ills. 5500 w. Nature—Dec. 8, 1904. No. 66716 A.

Aluminum.

Making Castings in Aluminum. Briefly considers points which need attention to insure successful work. 900 w. Sci Am Sup—Dec. 24, 1904. No. 66903.

Brass.

Successful Brassfounding. John F. Buchanan. Read at the A. F. A. convention. A brief review of the history of brassfounding, with suggestions for producing successful work. 4000 w. Foundry—Dec., 1904. No. 66678.

Refractory.

A Study of Refractory Materials (Etude sur les Matériaux Réfractaires). M. A. Morel. An examination of the properties of materials employed to resist high temperatures, including graphite, silica, alumina, lime and the various fire clays. 4000 w. Revue Technique—Nov. 25, 1904. No. 66835 D.

Steel.

Heat Treatment Experiments with Chrome-Vanadium Steel. H. Riall Sankey and J. Kent Smith. An account of tests made to determine the effect of the addition of vanadium in varying proportions to pure carbon steels and to steels containing small percentages of chromium and nickel. Describes apparatus used and methods of making the tests, comparing results. Ills. 8400 w. Inst of Mech Engrs —Dec. 16, 1904. No. 66904 D.

Testing.

Modes of Testing Castings. W. T. MacCall. Abstract of a paper read before the British Found. Assn. Describes briefly the various tests applied to cast iron, and to some other metals. 2000 w. Ir & Coal Trds Rev—Dec. 9, 1904. No. 66739 A.

The Testing of Metals by the Flexion of Notched Bars (Sur l'Essai des Métaux par Flexion de Barreaux Entaillés). G. Charpy. Describing the use of a special form of ballistic pendulum for producing impact tests upon small notched bars of metal. 5000 w. Mem Soc Ing Civ de France—Oct., 1904. No. 66850 G.

Tool Steels.

Profit in the Use of High-Speed Steel Tools. A discussion of this subject, illustrating by a typical example. 2000 w. Ir Age—Dec. 1, 1904. No. 66466.

MEASUREMENT.

Mechanical Science.

Some Refinements of Mechanical Science. Ambrose Swasey. Presidential address on the methods and mechanisms which have been developed and perfected to a high degree of precision, such as clocks, sextants, and other instruments for measurement. 5000 w. Trans Am Soc of Mech Engrs, No. 058—Dec., 1904. No. 66512.

Metric System.

The Inch Versus the Meter for a Universal Metric System. George Moores. Discusses this subject, favoring the inch as the universal measure. 2400 w. Cassier's Mag—Dec., 1904. No. 66462 B.

Standards.

Volumetric Standards for Technical Work. W. J. Sharwood. Showing how limited is the number of fundamental substances which are actually required to standardize the more important solutions in ordinary use. 1200 w. Cal Jour of Tech —Oct., 1904. No. 66418 C.

Tanks.

Calculating Diagrams for Capacities of Tanks, Etc. E. C. de Wolfe. Gives diagram for estimating approximately the capacity of tanks, cisterns, or other vessels, or for finding the quantity of their contents when partially filled. 2700 w. Power —Dec., 1904. No. 66596 C.

POWER AND TRANSMISSION.

Air.

The Mechanical Transport of Air. W. B. Snow. A fully illustrated account of the manner in which the fundamental problems of ventilation and draft have been solved. 3000 w. Engineering Magazine—Jan., 1905. No. 66891 B.

Air Compressors.

Air Compressors and Their Valve Gear. Charles Hurst. An illustrated article comparing the merits of automatic and positive valve-compressors. 2500 w. Engng Rev—Dec., 1904. No. 66719 B.

Air-Compressor Tests (Versuche an Luftkompressoren). Data and results of two air compressors in actual service. 2000 w. Glückauf—Nov. 12, 1904. No. 66880 B.

Cone Pulleys.

A Diagram for Cone Pulley and Back

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Gear Problems. Gives diagram, with directions for use. 500 w. Am. Mach—Vol. 27, No. 49. No. 66544.

Conveyors.

Electrically Driven Conveyors (Elektrisch Betriebene Schwebetransporte). G. Dieterich. Illustrating and describing a variety of overhead devices carrying electric trolleys for conveying material. Two articles. 6000 w. Zeitschr d Ver Deutscher Ing—Nov. 12, 19, 1904. No. 66805 each D.

The Use of Electricity in Driving Coal Conveying Machinery. Frank C. Perkins. An illustrated description of apparatus at the works of a large steel company at Sparrow's Pt., Md. 700 w. Sci Am—Dec. 10, 1904. No. 66558.

Cranes.

The Shaw Electric Crane at the World's Fair. Illustrated description, with details of special features of the crane awarded the grand prize in Group 64. 800 w. Ir Age—Dec. 1, 1904. No. 66463.

Elevators.

The Aero-Hydraulic Elevator. William Baxter, Jr. Illustrated description of a system in which the water pressure required to operate the car is obtained by means of compressed air or steam. 1600 w. Engr, U S A—Dec. 15, 1904. No. 66696 C.

Handling.

Labor Saving in the Handling of Materials. A. J. S. B. Little. A fully illustrated description of the increasing use of conveying machinery in general manufacturing plants. 4000 w. Engineering Magazine—Jan., 1905. No. 66893 B.

Modern Coal and Ore Handling Machinery. Henry S. Fleming. Illustrates and describes a few modern systems for the mechanical handling of materials. 2000 w. Min Mag—Dec., 1904. No. 66519 C.

Heat Motor.

The Athermic Motor (Moteur Athermique). Leo Dex. A description of a machine operating by the utilization of extremely low temperatures, employing liquid carbonic acid. Serial. Part I. 7000 w. Revue Technique—Dec. 10, 1904. No. 66836 D.

Prime Movers.

Notes on Power Production. William McClellan. Discusses the reliability and cost of steam engines, steam turbines and gas engines, and the outlook. 5400 w. Eng News—Dec. 29, 1904. No. 66942.

Ropes.

Rope Driving. A consideration of points conducive to successful rope-driving. 1500 w. Col. Guard—Dec. 9, 1904. No. 66730 A.

The Transmission of Power by Ropes. Edwin Kenyon. A discussion of conditions where the transmission of power by ropes is more economical, and the applications that may be made of this method of driving, the different systems, and all details connected with them. Ills. 11700 w. Trans Inst of Engrs & Shipbuilders—Nov. 22, 1904. No. 66909 D.

Safety Appliances.

Recent Safety Appliances for Cotton Mules. J. H. Crabtree. Illustrated descriptions of scroll and pulley-guards for the prevention of accidents. 1800 w. Engng Dec. 2, 1904. No. 66635 A.

Wind Motor.

The Conical Wind Motor. Dr. Alfred Gradenwitz. Gives some results of experiments made by Prof. La Cour for the Danish Government. Ills. 800 w. Elec Rev, Lond—Dec. 16, 1904. No. 66916 A.

STEAM ENGINEERING.

Bearings.

Engine-Shaft Bearings. William Turner. Abstract of a paper read before the Manchester Assn. of Engrs. A criticism of views advanced in a paper by "A Naval Engineer," with discussion of the proper adjustment of bearings, and related subjects. 2500 w. Mech Engr—Dec. 3, 1904. Serial. 1st part. No. 66627 A.

The Determination of the Length of a Crank Shaft Bearing (Die Bestimmung der Länge eines Kurbellagers). Prof. O. Grove. An examination of the distribution of pressures upon the main bearing adjacent to an engine crank. 3000 w. Zeitschr d Ver Deutscher Ing—Nov. 19, 1904. No. 66810 D.

Boilers.

A Comparison of Vertical and Horizontal Tubes in Water-Tube Boilers. W. R. Cummins. Abstract of a paper read before the North-East Coast Inst. of Engrs. Written to raise a discussion on the relative merits of vertical and horizontal tubes in water-tube boilers. Ills. 4000 w. Ir & Coal Trds Rev—Dec. 2, 1904. No. 66642 A.

Latest Type of Babcock & Wilcox Marine Boiler. R. K. Crank. Illustrates and describes details of the design and construction. 6500 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66759 H.

Test of a Niclausse Boiler Under Forced Draft. W. M. Parks. A report of tests made to determine whether the proportions of the boiler were such that it could be forced to a high rate of coal combustion without injury. Ills. 3500 w. Jour Am Soc of Nav Engrs—Nov., 1904. No. 66755 H.

Boiler Tests.

Notes on Boiler Tests. J. E. Bell. Read before the Ohio Soc. of Mech., Elec., and

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Steam Engrs. Suggestions for making a complete boiler test in the right way, with remarks on tests made. 3500 w. Engr, U S A—Dec. 1, 1904. No. 66427 C.

Chimney.

See Civil Engineering and Construction.

Combustion.

The Relation of the Volume of Hot Gases to the Heat Generated (Abhängigkeit des Ranchgasvolumens von der Erzeugten Wärmemenge und ihre Anwendung). A. Dosch. An examination of the conditions of combustion in boiler furnaces, with especial reference to the influence of the volume of gases to the transfer of heat. Two articles. 7000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 18, 25, 1904. No. 66819 each D.

Economy.

The Best Economy of the Piston Steam Engine at the Advent of the Steam Turbine. J. E. Denton. Read before the Int. Cong. of Arts and Sciences at St. Louis. Reviews the development of steam-engine economy in engines of various types, showing that the turbine is already a formidable competitor. 5000 w. Eng News—Dec. 8, 1904. No. 66553.

Engine Tests.

Interesting Results of the Tests of a Reeves Simple Engine. Prof. R. C. Carpenter, assisted by Prof. H. Diederichs. Describes tests made at Sibley College. 1200 w. Wis Engr—Dec., 1904. No. 66906 D.

Exhaust Steam.

The Utilization of Exhaust Steam (L'Utilisation des Vapeurs d'Echappement). P. Chaleil. A review of the Rateau steam accumulator, and its application to the regulation of exhaust steam for use in the low-pressure steam turbine. 3500 w. Rev Gen d Sciences—Nov. 30, 1904. No. 66853 D.

The Utilization of the Exhaust Steam of Intermittent Motors (Abdampf-Verwertung Intermittierender Maschinen in Berg und Hüttenwerken). W. Küppers. With especial reference to the use of the Rateau steam accumulator for equalizing exhaust steam pressures for use with the low-pressure steam turbine. 1800 w. Glasers Annalen—Nov. 15, 1904. No. 66827 D.

Explosions.

Boiler Explosions (Sur les Explosions de Chaudières). L. Le Cornu. A discussion of the dynamic effects due to the sudden liberation of highly heated water in a boiler explosion; with especial reference to the explosion of a locomotive at the Gare St. Lazare, July 4, 1904. 1200 w. Comptes Rendus—Nov. 7, 1904. No. 66840 D.

Feed-Water.

Boiler Feed Waters and Scale. A. M. Wickens. Read before the Can. Soc. of Chem. Ind. Suggestions on the care of boilers and improvement of feed waters. 2400 w. Can Engr—Dec., 1904. No. 66588.

Purifying Boiler Feed-Water. R. T. Strohm. Discusses the various methods in use, illustrating a live steam purifier and describing its advantages. Considers an analysis of the water to be treated necessary and a system adopted to meet each case. 2500 w. Am Elect'n—Dec., 1904. No. 66494.

Qualitative Testing of Feed Water. William H. Jenkins. Gives methods by which any engineer can determine the character of the impurities in the feed water he is using. Ills. 2400 w. Power—Dec., 1904. No. 66602 C.

Water Softening. A. H. Jackson. Presidential address to the Incor. Inst. of Analysts, Assayers, and Metallurgists. Remarks on the advantages of treating water before entering the boiler, with review of the Archbutt-Deely process, are given in the present number. Ills. 3400 w. Aust Min Stand—Nov. 10, 1904. Serial. 1st part. No. 66724 B.

Fire Engines.

The Modern Steam Fire Engine. F. F. Loomis. Read before the Ohio Soc. of Mech., Elec., and Steam Engrs. A review of the history of steam fire engines, and a discussion of the requisites for a modern steam fire engine. 2000 w. Engr, U S A—Dec. 1, 1904. No. 66428 C.

Fly-Wheels.

The Design of Fly-Wheels. A. H. Gibson. Considers the design and construction, showing the conditions which they must fulfil under certain circumstances, and the suitability of various designs for fulfilling these conditions. Ills. 3500 w. Engng Rev—Dec., 1904. Serial. 1st part No. 66718 B.

Fuel Economy.

Boiler Fuel Economy in a Water-Gas Works. J. A. Perry. Considers in detail the steps necessary to insure the best economy and indicates where certain mistakes in installation should be avoided. 4400 w. Pro Age—Dec. 15, 1904. Serial. 1st part. No. 66645.

Inspection.

The Inspection of a High-Speed Engine after Overhauling. Describes a method of examination recommended before running up an engine after it has left the fitters' hands. 2000 w. Elec Rev, Lond—Dec. 2, 1904. No. 66630 A.

Lubrication.

Lubricating the Valves and Cylinder. J.

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W. Parker. Shows that to effectually lubricate the valves and pistons of a steam engine the oil must be applied on the upper sides of the parts to be lubricated. Ills. 1000 w. Power—Dec., 1904. No. 66599 C.

Oil Burners.

Steam vs. Air for Liquid Fuel and Oil Burners. From a paper by George G. Bennett, read before the Ohio Soc. of Mech., Elec., and Steam Engrs. On the advantages of oil as fuel, and the best ways of burning it. 2300 w. Am Mach—Vol. 27, No. 51. No. 66745.

Power Plants.

Power Plants of the Atlas Portland Cement Co. An illustrated detailed description of the power equipment of the Northampton, Pa., mills of this company. 6000 w. Power—Dec., 1904. No. 66594 C.

Rotary Engine.

The Hoffman Rotary Engine. An illustrated description of what is said to be the first rotary engine which has reached the stage of commercial manufacture. 2000 w. Ir Age—Dec. 29, 1904. No. 66936.

Smoke.

Discussion of F. J. Rowan's Paper on "The Smoke Problem." 6000 w. Trans Inst of Engrs & Shipbuilders—Nov. 22, 1904. No. 66908 D.

Speed Variations.

Steam Engines for the Parallel Driving of Alternators (Die Dampfmaschinen für den Antrieb Parallel Arbeitender Wechselstromgeneratoren). H. Holtze. An examination of the periodical speed variations of various combinations of reciprocating engines in connection with their influence upon the action of parallel-connected alternators. 6000 w. Elektrotech Zeitschr—Dec. 15, 1904. No. 66867 B.

Steam Engines.

Heavy Duty Engines in Steel Plants. Arthur L. Strickland. Read before the Ohio Soc. of Mech., Elec., and Steam Engrs. Briefly describes the exterior process of manufacturing Bessemer steel, and the heavy duty engine service, explaining the kinds of engines used and the work expected of them. 1500 w. Ir Trd Rev—Dec. 1, 1904. No. 66431.

Piston-Valve Engine at the Mulhouse Electric Station (Machines à Vapeur à Pistons-Valves de la Nouvelle Centrale d'Electricité de Mulhouse). Fr. Lamey. Describing a cross-compound engine of which each cylinder is provided with four independently operated piston valves. 1800 w. 1 plate. Génie Civil—Nov. 19, 1904. No. 66801 D.

Some Large Engines in the Power Plant of the St. Louis Exhibition. An illustrated article dealing with details of the Reynolds-Corliss, Hamilton-Corliss, Willans, and Greenwald Four-Valve Engines. 2500 w. Eng News—Dec. 8, 1904. No. 66552.

Steam Engine with Piston Valves (Dampfmaschinen mit Kolbenschiebersteuerung). F. Lamey. Illustrated description of tandem compound condensing engine of 1000 h. p., with piston valves and Frikart valve gear, exhibited at St. Louis by the Elsass Machine Works, of Mulhouse. 2500 w. 1 plate. Zeitschr d Ver Deutscher Ing—Dec. 10, 1904. No. 66814 D.

The Scottdale Corliss Engine. Illustrated description of a new design having several novel features. 2000 w. Ir Age—Dec. 8, 1904. No. 66540.

Steam Piping.

High and Low-Pressure Steam Piping of the New York Subway Power House. Franz Koester. An illustrated detailed description of the pipe lines for distributing steam through this plant. 1800 w. Engr, U S A—Dec. 1, 1904. No. 66426 C.

Steam Turbines.

The Future of the Steam Turbine. Editorial on the future of the turbine in various ships, referring only to the Parsons system. 2400 w. Engng—Nov. 25, 1904. No. 66535 A.

The Steam Turbines of the St. Louis Exposition. Illustrated description of the Curtis steam turbine, and the Westinghouse-Parsons turbine. 2500 w. Power—Dec., 1904. No. 66600 C.

The Steam Turbine in a Refuse Destruction Plant. Dr. Alfred Gradenwitz. Describes the plant at Zurich, Switzerland. 1000 w. Munic Engng—Dec., 1904. No. 66652 C.

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Stoker.

The Jones Underfeed Stoker. Report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of Evan William Jones, giving illustrated detailed description of the apparatus. 5000 w. Jour Fr Inst—Dec., 1904. No. 66670 D.

MISCELLANY.

Aeronautics.

A New Method of Constructing Aerial Screw Propellers (Sur un Nouveau Mode de Construction des Helices Aériennes). Ch. Renard. Describing a form of braced propeller of light weight and great stiffness; adapted for flying machines. 1500 w. Comptes Rendus—Nov. 7, 1904. No. 66839 D.

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Experiments with the Airship "Mediterranean II." F. Payrey. Translated from *La Vie Automobile.* An account of experiments made, with the results. 1200 w. Sci Am Sup—Dec. 3, 1904. No. 66455.

Exhibition.

The International Exhibition at St. Louis, U. S. A. Walter Francis Reid. A brief account of the buildings and their contents, with remarks. Discussion. 9000 w. Jour Soc of Arts—Dec. 9, 1904. No. 66714 A.

Invention.

Studies in Invention. Leicester Allen. Introduction to a series of problems of educational value, calling for solutions and stating requirements. The first problem is also given. 1200 w. Am. Mach.—Vol. 27. No. 48. Serial. 1st. part. No. 66415.

MINING AND METALLURGY

COAL AND COKE.

Accidents.

Fatal Accidents in Coal Mining in 1903. Frederick L. Hoffman. A careful study of coal mine accidents in the United States. 1600 w. Eng & Min Jour—Dec. 22, 1904. No. 66760.

Alberta.

Geological Sketch of the Bankhead Coal Field. J. M. Turnbull. An illustrated article describing an unusual formation, and giving brief account of development, and other information. 2700 w. Can Min Rev—Nov. 30, 1904. No. 66482 B.

Coal Production.

See Industrial Economy.

Coal-Screening.

Coal-screening Plant. Illustrates and describes the plant at the Thryburgh Colliery, Kilnhurst. 2000 w. Engr, Lond—Dec. 2, 1904. No. 66641 A.

Coal Washing.

Coal Washing in Alabama. Erskine Ramsay and Charles E. Bowron. Reports an increase in the use of the process, illustrating and describing plants using Stewart washers and Robinson-Ramsay washers. 3500 w. Mines & Min—Dec., 1904. No. 66568 C.

Coal Washing in Great Britain. James Tonge. A description of the various methods employed and the different types of jiggers, trough washers, and wasting tables, giving costs. Ills. 5800 w. Mines & Min—Dec., 1904. No. 66565 C.

Tercio and Cuatro Mines. R. M. Hosea. An illustrated description of the coal washing and coking plants of the Colorado Fuel & Iron Co. 5500 w. Mines & Min—Dec., 1904. No. 66566 C.

Peat.

Bog Fuel. Edward Atkinson. An interesting account of the writer's experimental investigations and the results, with brief discussion. 4500 w. Jour N Eng W-Wks Assn—Dec., 1904. No. 66752 F.

Small Coal.

Small Size Anthracite. Samuel Sanford. Information in regard to the rapid increase in the consumption of the small sizes, and the amounts recently recovered by the washeries. 2200 w. Eng & Min Jour—Dec. 22, 1904. Serial. 1st part. No. 66761.

COPPER.

Boundary District.

The Granby Copper Mine. Dwight E. Woodbridge. An illustrated account of the location anl special features, methods of mining, the smelter, &c. 2500 w. Ir Age—Dec. 1, 1904. No. 66464.

British Columbia.

Britannia Mines, Howe Sound, B. C. William M. Brewer. An account of the development of mines near Vancouver, carrying high values in copper. 4500 w. Min & Sci Pr—Dec. 17, 1904. No. 66796.

Mining in the "Similkameen" Yale District, British Columbia. Frank Bailey. An illustrated account of this district, its natural beauty and wonderful resources. Rich copper deposits, mineral and coal fields, gold, platinum, &c., but copper predominates. 2400 w. Min Rept—Dec. 22, 1904. No. 66793.

Concentration.

The Washoe Reduction Works. An illustrated description of the concentrator at the plant of the Anaconda Copper Mining Co. at Anaconda, Montana. 1800 w. Mines & Min—Dec., 1904. No. 66573 C.

Determination.

A Modification of the Iodide Method for the Determination of Copper. J. H. Burfeind. Gives a general description of the method suitable for all ores and furnace materials under all conditions. 1600 w. Min Rept—Dec. 15, 1904. No. 66703.

Electro-Deposition.

See Electrical Engineering, Electrochemistry.

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Hot Blast.

Hot Blast Generation. Herbert Haas. On the use of the hot-blast stove in copper smelting, with critical discussion of various types, and illustrated description of the design by the author. 2500 w. Eng & Min Jour—Dec. 29, 1904. No. 66949.

Low Grade Ores.

Notes on the Cyanide Method on Low Grade Copper Ores. James W. Howson. Describes the method as used by the author. 900 w. Cal Jour of Tech—Oct., 1904. No. 66421 C.

Manufacturing.

Martin's Improved Method of Manufacturing Copper by Direct Rolling with the Initial Refinery Heat. H. J. Martin. A description of this process with detailed plan of plant. 2000 w. Ir & Coal Trds Rev—Dec. 9, 1904. No. 66737 A.

Ores.

How Copper is Produced. Ralston Bell. Briefly describes the minerals which are important as sources of copper and considers the occurrence and treatment of the principal ores. 1800 w. Min Rept—Dec. 14, 1904. Serial. 1st part. No. 66701.

GOLD AND SILVER.

Amalgamation.

The Testing of Gold Ores by Amalgamation. Ernest A. Hersam. Describes methods of laboratory-amalgamation, discussing the effect of the size of the test-portion. 4500 w. Min Wld—Dec. 10, 1904. Serial. 1st part. No. 66584.

Assaying.

Determination of Silver in Ores in the Wet Way. F. Altneder. Describes an assay method for prospectors which dispenses with the heavy assay outfit and necessary accessories and with the expensive and delicate assay balances. 1200 w. Min & Sci Pr—Nov. 26, 1904. No. 66500.

California.

The Gold Mines of Angels, Cal. An illustrated article giving information of one of the oldest and most noted mining districts of California. 1200 w. Min & Sci Pr—Nov. 26, 1904. No. 66501.

Concentration.

Wet Concentration. Frederic Wooster Sherman. Describes methods by which minerals susceptible to this process can be recovered to a high percentage. Ills. 2800 w. Mines & Min—Dec., 1904. No. 66570 C.

Cripple Creek.

Current Practice at Cripple Creek. G. E. Wolcott. Describes the methods in use and the difficulties of concentration, ore-sorting, washing, &c. 2000 w. Eng & Min Jour—Dec. 8, 1904. No. 66551.

Crushing.

Fine Crushing of Banket Ore. W. A. Caldecott. Abstract of a paper read before the Inst. of Min. & Met., London. On the results of recent practice in the Rand. 1000 w. Eng & Min Jour—Dec. 15, 1904. No. 66692.

Some Comparisons Between Dry Crushing and Wet Crushing in Cyanide Solution. John T. Millikin. Abstracted from a paper on the practice of the dry crushing Imperial mill in the Black Hills. Comparisons with the fine wet crushing plants, discussing some features of dry crushing. 2000 w. Min Rept—Dec. 22, 1904. No. 66794.

Dredging.

Gold Dredging at Oroville. Howard D. Smith and Elwyn W. Stebbins. Describes the character of the ground, which is peculiarly favorable to dredge operations, and the types of dredges and methods used. Also gives a summary of the operating expenses. 4400 w. Eng & Min Jour—Dec. 8, 1904. No. 66550.

India.

Gold in British India. J. Malcolm Maclaren. Information concerning the Chota Nagpur field. 2500 w. Aust Min Stand—Nov. 10, 1904. No. 66723 B.

Nevada.

The New Gold Camps of Southern Nevada. An illustrated description of the mines of the Goldfield district. 5000 w. Min & Sci Pr—Nov. 26, 1904. No. 66502.

Ore Treatment.

A New Process for Treating Silver Sulphide and Gold Ore. M. Vaygouny. An account of experimental investigations with a solution of ferric chloride, common salt and hydrochloric or sulphuric acid. 2500 w. Eng & Min Jour—Dec. 29, 1904. No. 66951.

The New Chlorination. William E. Greenawalt. A comparison of chlorination and cyanidation, reporting tests made, and giving interesting information of recent development. Ills. 2200 w. Eng & Min Jour—Dec. 1, 1904. No. 66435.

Refining.

Lead and Silver Refining at the Canadian Smelting Works, Trail, B. C. E. Jacobs. A brief description of the general plant and operations of the smelter, with illustrated detailed description of the electrolytic lead refinery. 3300 w. B C Min Rec—Dec., 1904. No. 66546 B.

Re-grinding.

Re-grinding at El Oro. Charles Butters and E. M. Hamilton. Abstract of a paper read before the Inst. of Min. & Met.,

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London. An account of the latest practice and the results. Also notes from the discussion of the paper. 2500 w. Eng & Min Jour—Dec. 15, 1904. No. 66690.

Separation.

The Separation of Sands from Slimes in the Cyanide Process. Charles H. Fulton. Describes the systems used in the Homestake and Hidden Fortune mills. 2800 w. Mines & Min—Dec., 1904. No. 66571 C.

Yukon.

Auriferous Bench Diggings of Bonanza, Yukon Territory. Describes the locality, with remarks on the probable source of the gold. 1000 w. Min & Sci Pr—Dec. 3, 1904. No. 66593.

IRON AND STEEL.

Blowing Engines.

The Loss of Pressure in Blowing-Engine Valves (Druckverluste in Gebläseventilen). Prof. L. Klein. Describing experiments upon the relation of lift to pressure loss in air valves of blowing engines operated at high speeds. 1000 w. Zeitschr d Ver Deutscher Ing—Nov. 12, 1904. No. 66808 D.

Cementation.

The Surface Hardening of Steel. Illustrated description of the manner in which the operation of cementation is effected, as given in a paper by Léon Guillet. 2000 w. Ir & Coal Trds Rev—Dec. 9, 1904. No. 66738 A.

Charging.

A New Blast Furnace Charging Device. An illustrated description of the Backlund & Burman furnace charging apparatus and its operation. 1700 w. Ir Age—Dec. 29, 1904. No. 66937.

Dry Air.

The Application of the Dry-Air Blast to Blast Furnace Operation (Die Verwendung von Trockenem Gebläsewind im Hochofenbetrieb). A full account of the Gayley dry-air blast as applied at the Isabella furnace. 3500 w. Stahl u Eisen—Nov. 15, 1904. No. 66883 D.

The Dry Air Freezing Process at the Isabella Furnace (Congélation de l'Humidité de l'Air Soufflé aux Hauts Fourneaux Isabella, pres Pittsburgh). MM. Picard & Heurteau. A brief account of the Gayley process of drying the air blast by freezing out the moisture. 1000 w. Comptes Rendus—Nov. 21, 1904. No. 66841 D.

The Influence of Drying the Blast on Blast-Furnace Performance (Influence Exercée par la Desiccation du Vent sur la Marche des Hauts Fourneaux). A. Lodin. A discussion of the Gayley dry air blast process, indicating that the reported economy may be due to other causes. 1200 w. Comptes Rendus—Nov. 28, 1904. No. 66842 D.

The Use of Dry Air in Blast Furnaces (Sur l'Emploi de l'Air Sec dans les Hauts Fourneaux). Henri Le Chatelier. An examination of the Gayley dry air process, showing that the economy may be due to the operation at a lower temperature. 1000 w. Comptes Rendus—Nov. 28, 1904. No. 66843 D.

Electro-Metallurgy.

See Electrical Engineering, Electro-Chemistry.

Furnaces.

The New Cleveland Furnace. Brief, illustrated description of the plant of the Cleveland Furnace Company. 2400 w. Ir Age—Dec. 22, 1904. No. 66742.

Handling.

Mechanical Handling in the Manufacture of Iron and Steel. James N. Hatch. The influence of labor saving machinery in the steel industry upon national economy. 4000 w. Engineering Magazine—Jan., 1905. No. 66894 B.

Iron Working.

Iron and Its Early Manufacture in England. A. R. Bell. A brief review of the early history of iron working in England. Ills. 2000 w. Mach. N. Y. Dec., 1904. No. 66605 c.

Iron Works.

The Jeanesville Iron Works Company. Illustrated description of a modern plant arranged with a view to obtaining low shop cost and the greatest perfection in the product. 1400 w. Ir Age—Dec. 1, 1904. No. 66465.

Magnetite.

Genesis of the Magnetite Deposits in Sussex Co., New Jersey. Arthur C. Spencer. Shows the geologic relation of these magnetites, and the manner in which they were formed. 2000 w. Min Mag—Dec. 1904. No. 66518 C.

Pig Iron.

The Classification and Valuation of Pig Iron (Einteilung und Bewertung des Giessereiroheisens). Oscar Simmersbach. With especial reference to the grading of German pig iron according to the percentage of silicon. 3000 w. Glückauf—Nov. 19, 1904. No. 66882 B.

Separators.

Electro-Magnetic Separators of the Secondary Induction Type. Explanation, with illustrated description of the Knowles magnetic separator and its operation. 3000 w. Mines & Min—Dec., 1904. No. 66567 C.

Sulphur.

The Use of Manganese Ore as a Desulphuriser in the Melting of Pig Iron

(Ueber die Verwendung von Manganerzen als Entschwefelungsmittel beim Schmelzen von Gusseisen). Dr. Wedemeyer. With analyses from a number of trials, showing the beneficial action of manganese ore in remelting. Two articles. 5000 w. Stahl u Eisen—Nov. 15, Dec. 1, 1904. No. 66886 each D.

Wisconsin.

Iron Ores of Wisconsin with Special Reference to the Baraboo District. S. Weidman. Read before the Science Club of the Univ. of Wis. Considers briefly the three kinds of iron ores in the state, especially describing the Baraboo district, its geology, deposits, development, &c. 4500 w. Wis Engr—Dec., 1904. No. 66907 D.

Progress on the Baraboo Iron Range. D. E. Woodbridge. Remarks on Mr. Weidman's conclusions as to the genesis of this ore, with information and opinions of W. G. La Rue. Ills. 2500 w. Ir Trd Rev—Dec. 29, 1904. No. 66948.

MINING.

Alkali Lakes.

The Alkali Lakes of the San Luis Valley. Prof. Herman Fleck. Read before the Western Assn. of Tech., Chem. & Met. Gives the location of these lakes, describing them and discussing their origin, general properties, &c. 1000 w. Min Rept—Dec. 15, 1904. No. 66702.

British Columbia.

Review of British Columbia Mining. H. Mortimer Lamb. 2300 w. Min Rept—Dec. 8, 1904. No. 66583.

Broken Hill.

Geology of the Broken Hill Lode. F. S. Mance. An explanation of the geology of these mines in New South Wales, giving views of various investigators, supporting the opinion that the lode is a saddle. 1500 w. Eng & Min Jour—Dec. 1, 1904. No. 66433.

Zinc at Broken Hill. F. H. Bathurst. An account of the big stores of zinc in the mines and in the dumps, and its value. 1400 w. Eng & Min Jour—Dec. 1, 1904. No. 66434.

Cleavage.

Cleavage. George F. Becker. Abstract from "Experiments on Schistosity and Slaty Cleavage." Bulletin No. 241, U. S. Geol. Survey. Describes phenomena found in rocks, giving theories explaining the causes. 1400 w. Eng & Min Jour—Dec. 1, 1904. No. 66432.

Computations.

The Computation of the Dimensions of Mine Workings (Die Berechnung der Abmessungen von Abbaufeldern). H. Kegel. A derivation of elaborate formulas for computing the most economical areas for mine workings. 10000 w. Glückauf—Nov. 19, 1904. No. 66881 B.

Concentration.

Concentration of Ores in Great Britain. James Tonge. Describes the general practice, giving the principal features of a number of the most modern plants. 3500 w. Mines & Min—Dec., 1904. No. 66574 C.

Crushing for Concentrating Work. Discussing the process of crushing; the types of machines, with special reference to the Blake crusher. Ills. 3000 w. Mines & Min—Dec., 1904. No. 66569 C.

Electric Power.

An Installation of Electric Power for a Quebec Mine. Describes the substitution of electricity, generated by water power, for steam power at the Eustis mine at Capelton, P. Q. The mine produces sulphur, copper and the precious metals. Ills. 2000 w. Can Min Rev—Dec. 31, 1904. No. 66797 B.

Electric Drilling, Dredging and Pumping. George E. Walsh. Information in regard to the cost of operation, and applications at various mines. 2000 w. Eng & Min Jour—Dec. 15, 1904. No. 66691.

Electricity in the Lanarkshire Coalfield. Abstract of a presidential address delivered by Robert Robertson before the Glasgow Local Sec. of the Inst. of Elec. Engrs. 3000 w. Col Guard—Dec. 16, 1904. No. 66911 A.

The Copper Age Reservoir. Brief description, with diagrams, of plans for a power plant near Victor, Colorado, which will furnish electric power to the Victor and Cripple Creek mines. A granite masonry dam will be built at a point having unexcelled natural advantages. 800 w. Min Rept—Dec. 15, 1904. No. 66700.

Electric Prospecting.

Ore Finding by Electric Waves. Extracts from a paper by Alfred Williams explaining the application of the Daft and Williams process. Ills. 2400 w. Elec-Chem & Met—Dec., 1904. No. 66659 C.

Machinery.

Labor-Saving Devices in Coal Mining. R. V. Norris. An account of the manner in which some of the labor problems in coal mining have been met by the introduction of improved machinery. 3500 w. Engineering Magazine—Jan., 1905. No. 66892 B.

Mine Air.

The Dust in the Air and the Gases from Explosives in Dolcoath Mine. R. Arthur Thomas and W. P. O. Macqueen. An account of an investigation under-

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taken to determine the amount of stone dust present in the air, the efficacy of water jets and other means for preventing dust, and the amount of gaseous impurities present after blasting. 2500 w. Ir & Coal Trds Rev—Dec. 16, 1904. No. 66929 A.

Mine Pumping.

See Mechanical Engineering, Hydraulics.

Mining Power.

Power Generation and Transmission in a Modern Mine. E. H. Roberton. A discussion of the peculiar limitations and requirements involved in the installation of power generating and transmitting installations in mines. 3000 w. Engineering Magazine—Jan., 1905. No. 66897 B.

Oregon.

Producing Mines of Eastern Oregon. Describes the formation of the country and gives information of the principal workings, with illustrations. 2500 w. Min & Sci Pr—Dec. 3, 1904. No. 66592.

Ore Washing.

Brown-Ore Washing in Alabama. Erskine Ramsay and Charles E. Bowron. An illustrated description of construction and method of operation of log washers, stating the conditions to which they are adapted. 1400 w. Mines & Min—Dec., 1904. No. 66572 C.

Pneumatic Drills.

Recent Trials with Pneumatic Rock Drills (Neuere Versuche mit Luftbohrmaschinen). F. Hempel. Tabulated results of experiments with a number of German rock drills, showing the work done for a given consumption of air. 1800 w. Glückauf—Nov. 12, 1904. No. 66879 B.

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Queensland.

Certain Iron Ore, Manganese Ore, and Limestone Deposits in the Central and Southern Districts of Queensland. Lionel C. Ball. Illustrated descriptions of these deposits with account of their development. 9800 w. Queens Gov Min Jour—Oct. 15, 1904. Serial. 1st part. No. 66469 B.

Reduction.

Washoe Reduction Works, Anaconda, Montana. Illustrated detailed description of the most extensive plant of its kind in the world, treating about 5500 tons of ore in 24 hours. 3800 w. Min Wld—Dec. 24, 1904. No. 66787.

Separator.

The Blake-Morscher Electro-Static Separator. Ernest A. Weinberg. Read before the Inst. of Min. & Met. An illustrated description of this separator, with explanation of the principle involved, and giving some practical working results. 3700 w. Min Jour—Nov. 26, 1904. No. 66520 A.

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Washington.

Mt. Baker Mining District. J. D. Bone. Illustrated detailed description, with map, of this mining district in Whatcom County and its development. 2500 w. Min Rept—Dec. 8, 1904. No. 66582.

MISCELLANY.

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Clays Found in South Carolina. Earle Sloan. The present number considers the clay bodies of the potter's art, sedimentary kaolins, paper stock kaolin, and fire clay. Ills. 2200 w. Brick—Dec., 1904. Serial. 1st part. No. 66516.

Diamonds.

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Gypsum.

A Theory of Origin for the Michigan Gypsum Deposits. G. P. Grimsley. Reviews the geology of this district, explaining the generally accepted theory of origin, and outlining the theory for these deposits. 3000 w. Am Geol—Dec., 1904. No. 66905 D.

Magnesite.

Magnesite and Its Uses. Charles H. Spinks. Describes the deposits in California, and explains some of the many uses to which the ore can be put. 2000 w. Cal Jour of Tech—Oct., 1904. No. 66416 C.

Natural Gas.

Natural Gas Pumping Plant at Hundred, W. Va. An illustrated detailed description of the station and machinery of this plant. 3000 w. Eng Rec—Dec. 17, 1904. No. 66683.

Laboratory.

A Modern Metallurgical Laboratory. Robert H. Bradford. An illustrated description of a complete plant for testing

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ores by various processes, at the State School of Mines, University of Utah. 1700 w. Mines & Min—Dec., 1904. No. 66575 C.

Lead-Zinc.

The Lead-Zinc Mines of Kansas and Missouri. W. R. Crane. An illustrated description of the present practice of mining and milling in the Joplin district. 4000 w. Mines & Min—Dec., 1904. No. 66564 C.

Oil Fields.

The Kansas Oil Fields. W. H. Heydrick. An illustrated article discussing the physical and commercial conditions. Map. 4700 w. Min Mag—Dec., 1904. No. 66517 C.

Phosphate.

Tennessee Phosphate. H. D. Ruhm. Abstract from *The American Fertilizer.* Describes the deposits and methods of mining. 1200 w. Eng & Min Jour—Dec. 29, 1904. No. 66950.

Tin.

Development of American Tin Deposits. Review of the industry by the United States Geelogical Survey. 1800 w. Ir Age—Dec. 8, 1904. No. 66541.

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RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

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Railroad Disasters in the United States. Egbert P. Watson. Discusses the causes of railroad disasters in the present day, attitude of the public, the best remedies available, etc. 2300 w. Ir Age—Dec. 29, 1904. No. 66938.

Baggage.

Report on the Question of Baggage (Subject XI, Littera A, for discussion at the 7th session of the Railway Congress). George H Daniels. 12800 w. 1 table. Bul Int Ry Cong—Nov., 1904. No. 66666 E.

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Advantages to be Derived from a Railway Clearance System. J. W. Midgley. A review of the Southern Iron Car Line, Green Line, and other attempts at clearing. 5500 w. Ry Age—Dec. 9, 1904. No. 66576.

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Fares.

Passenger Fares—An International Comparison. W. M. Acworth. Compares the Northeastern Railway of England with the railways of other countries, showing interesting results. 1500 w. Ry Age—Dec. 2, 1904. No. 66486.

International.

Statistics of International Transport (Statistique des Transports Internationaux). Gen. A. de Wendrich. A discussion of the necessity for a simplified system of regulating and recording international traffic on the Continental railways; with forms for recording statistics. 4000 w. Rev Gen d Chem de Fer—Dec., 1904. No. 66837 G.

Natal.

The Railways of Natal. J. F. Gairns. Illustrated description of their characteristics, trains and train service, traffic, etc. 6000 w. Cassier's Mag—Dec., 1904. No. 66457 B.

Problems.

Some Problems in Modern Railway Transportation. Philip Burtt. Extracts from a paper read at the meeting of the York Ry. Lecture and Debating Soc. Discusses problems bearing on the development and increase of business, and the economy. 4000 w. Transport—Dec. 2, 1904. No. 66619 A.

Train Orders.

The Middle Order and the "19" Order. H. A. Dalby. Discusses methods of handling train orders, especially the use of the "middle order." 2300 w. Ry Age—Dec. 2, 1904. No. 66487.

Visual Requirements.

Vision of Enginemen and Firemen in Railway Service: Some Factors Affecting Same. Dr. Nelson M. Black. An explanation of the trying conditions and the importance of perfect and quick vision, giving opinions of experts and conclusions. General discussion. Ills. 14400 w. Pro W Ry Club—Nov. 15, 1904. No. 66741 C.

Work Regulation.

Report No. 3 on the Question of the

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Duration and Regulation of Work (Subject XV for discussion at the 7th session of the Railway Congress). G. L. Potter. For America. 16800 w. 4 tables. Bul Int Ry Cong—Nov., 1904. No. 66667 E.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

A Remarkable Runaway. Amos Judd. An account of an air-brake failure with a light engine and tender, and the cause. 600 w. Loc Engng—Dec., 1904. No. 66513 C.

The Christensen Air-Brake. Illustrated detailed description. 1400 w. Engng—Dec. 9, 1904. No. 66732 A.

Cars.

Corridor Carriage for the Cambrian Railways. Two-page plate, with description. 800 w. Engng—Dec. 16, 1904. No. 66921 A.

Locomotive Frames.

The Locomotive Frame Considered as a Rigid Beam with Spring Supports (Der Lokomotivrahmen als Starrer Balken auf Federnden Stützen). W. Lindemann. A discussion of the various arrangements of springs and equalizing levers as distributing the load upon the frames of a locomotive. 3000 w. Glasers Annalen—Dec. 15, 1904. No. 66830 D.

Locomotives.

A Locomotive in Service Sixty Years. Herbert T. Walker. Illustration, with details of an engine in use nearly sixty years on a branch railroad in Santiago de Cuba. 800 w. Sci Am—Dec. 3, 1904. No. 66449.

Freight Locomotives with Superheaters, 2-8-0 Type. Illustrated detailed description of new engines for the Canadian Pacific Railway. 1500 w. Am Engr & R R Jour—Dec., 1904. No. 66437 C.

Locomotives at the St. Louis Exhibition. H. W. Hanbury. The first of a series of illustrated articles describing the locomotives exhibited. The present number deals with the locomotives built at the Rogers Locomotive Works. 2000 w. Engng—Dec. 2, 1904. Serial. 1st part. No. 66636 A.

Narrow-Gauge Consolidation Locomotive. Illustrated detailed description of powerful locomotives constructed for the Mexican Railways. 400 w. Engr, Lond—Dec. 2, 1904. No. 66639 A.

New Passenger Locomotives for the Lake Shore. Illustrated description, with general dimensions of the new Prairie (2-6-2) type passenger locomotives just put into service. 500 w. R R Gaz—Vol. XXXVII, No. 25. No. 66444.

Special Locomotive Types. J. F. Gairns. Begins a series of articles illustrating and describing some of these types. The present number illustrates two engines of the "Fairlie type"—double locomotives. 900 w. Prac Engr—Dec. 2, 1904. Serial. 1st part. No. 66625 A.

The Northern Pacific Mikado Locomotive. Illustrated description of heavy freight engines of the Mikado type, 2-8-2. 500 w. Ry Age—Dec. 9, 1904. No. 66577.

The Richmond Compound. H. C. Ettinger. An illustrated article giving a description of the proposed functions of this type of locomotive, and discussing its diseases and remedies. 700 w. Loc Engng—Dec., 1904. Serial. 1st part. No. 66514 C.

Three Historic Locomotives—and Some Others. Herbert T. Walker. Brief description, with illustrations of the principal historical additions to the collection owned by the Field Columbian Museum, recently exhibited at St. Louis. 1200 w. R R Gaz—Vol. XXXVII, No. 27. No. 66672.

Vanclain Four-Cylinder Balanced Compound Locomotive. Illustrated description of locomotives of the 4-6-0 type recently delivered to the New York, New Haven & Hartford Railroad. 500 w. Am Engr & R R Jour—Dec., 1904. No. 66439 C.

Locomotive Tests.

Instructive Tests of a Baldwin Balanced Compound Locomotive. Gives results of tests comparing this locomotive with three simple engines. The results are of special interest. 1500 w. Am Engr & R R Jour—Dec., 1904. No. 66438 C.

Locomotive Trade.

See Industrial Economy.

Motive Power.

Rock Island Motive Power Committee Report. Extracts from the recommendations and suggestions of the committee. 2400 w. R R Gaz—Vol. XXXVII. No. 29. No. 66956.

Refrigerator Cars.

New Types of Refrigerator Cars. Describes standard refrigerator cars, Bashaw's car, Fugazzi's temperable car, Johnson car, Bohn system car, Coolidge's car, S. & S. Sales car, and the fish commission car. Ills. 4000 w. Ice & Refrig—Dec., 1904. No. 66503 C.

Resistance.

Train Resistance. W. J. Davis, Jr. Gives information of value based on tests made from time to time with electric cars operated under a wide range of conditions, and the resistances obtained by ammeter and voltmeter readings. 2500 w. St Ry Jour—Dec. 3, 1904. No. 66491 C.

NEW PROJECTS.

Asia.

Russia's New Great Railroad in Asia. From the London *Times*. An account of the Orenburg-Tashkent Railway, with in-

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formation of interest in regard to the country traversed. 2000 w. Sci Am Sup—Dec. 3, 1904. No. 66454.

New Route.

The Great Western Company's New Route to the West. Illustrated description of the route known as the Castle Cary and Langport Railway. 1800 w. Engr, Lond—Dec. 9, 1904. No. 66735 A.

Simplon.

The Western Feeders of the Simplon Railway. Mr. Elskes, in *Schweizerische Bauzeitung*. 1700 w. 3 tables & fig. Bul Int Ry Cong—Nov., 1904. No. 66668 E.

PERMANENT WAY AND BUILDINGS.

Bridge Loading.

The Classification of Engines for Bridge Loading. C. D. Purdon. Describes a method of classification by which the strength of bridges and the weight of engines may be quickly compared to determine whether certain engines may be run over any division. 1000 w. Jour Assn of Engng Socs—Nov., 1904. No. 66699 C.

Circum-Baikal.

The Circum-Baikalien Railway (Die Baikal-Umgehungsbahn). A description of the difficulties, cost and construction of the section of the Siberian railway around Lake Baikal. 1000 w. Glasers Annalen—Nov. 15, 1904. No. 66828 D.

Culverts.

See Civil Engineering, Construction.

Cut-Off.

The Old Monroe-Mexico Branch of the Burlington. An illustrated description of a cut-off, requiring only the construction of 63 miles of new line to shorten the distance between St. Louis and Kansas City. 2000 w. R R Gaz—Vol. XXXVII, No. 25. No. 66442.

Floods.

Floods on the Santa Fe System. A. F. Robinson. Illustrated description of the remarkable results of floods on the Arizona division. 600 w. Ry Age—Dec. 16, 1904. No. 66693.

Rails.

On the Question of Rails for Lines with Fast Trains (Subject II for discussion at the 7th session of the Railway Congress). Report (No. 3) for America. P. H. Dudley. 31000 w. 14 tables & fig. Bul Int Ry Cong—Nov., 1904. No. 66664 E.

On the Question of Rails for Lines with Fast Trains (Subject II for discussion at the 7th session of the Railway Congress). Mr. Van Bogaert. Report for all countries, except America, Germany, Holland, Roumania, Russia, Denmark, Sweden, Norway and Switzerland. 24000 w. 1 table & fig. Bul Int Ry Cong—Nov., 1904. No. 66665 E.

Roaring Rails. H. L. Wilkinson. An account of an investigation into the cause of the rail surface being worn into a series of ridges which produce a deafening noise as the train passes over them. 2000 w. Ills. Engr, Lond—Dec. 2, 1904. No. 66638 A.

Roadbeds.

Oiled Roadbeds of Railways in California. Abstracted from Bulletin No. 2, Department of Highways of the State of California, Sacramento. 1700 w. Eng News—Dec. 1, 1904. No. 66424.

Shops.

Angus Locomotive and Car Shops, Montreal. Begins an illustrated detailed description of the largest railroad shop plant ever built and put into service at one time. A most interesting and instructive plant. 1400 w. Am Engr & R R Jour—Dec., 1904. Serial. 1st part. No. 66436 C.

Signal Lamps.

See Electrical Engineering, Lighting.

Signals.

Automatic Block Signals. Ralph Scott. Discusses siding protection, simple signal circuits, track circuit controlling, etc. Diagrams. 3500 w. Am Elect'n—Dec., 1904. No. 66495.

Block Signals and Other Safety Appliances as Used on Different Railroads. Jno. L. Davis. Concerning block signalling on a single track road. 5000 w. Pro St Louis Ry Club—Nov. 12, 1904. No. 66648.

Interlocking at St. Louis. Illustrated description of the interlocking plant controlling the entrance and departure of trains to and from the Union Station. 3-page plate. 1200 w. Ry Age—Dec. 16, 1904. No. 66694.

Station.

Norfolk & Western Station at Roanoke. Illustrated description of a fine passenger station under construction. 800 w. R R Gaz—Vol. XXXVII, No. 25. No. 66443.

The New Grand Central Station. Illustration, with brief description of a proposed station to be built on the present site. 1400 w. R R Gaz—Vol. XXXVII, No. 29. No. 66954.

TRAFFIC.

Suburban.

Suburban Traffic. Extracts from a report prepared by A. W. Sullivan for discussion at the International Railway Congress, with editorial. 3000 w. R R Gaz—Vol. XXXVII, No. 25. No. 66446.

MISCELLANY.

Foreign Practice.

Impressions of Foreign Railroad Practice. The present article deals especially with French methods, considering them

We supply copies of these articles. See page 876.

the most scientific treatment given to the locomotive at the present time. 1500 w. Am Engr & R R Jour—Dec., 1904. Serial. 1st part. No. 66441 C.

Germany.

The Development of Railways in the Ruhr District from 1840 to the Present (Entwicklung der Eisenbahnen in Ruhr-Industriegebiet Während der Zeit von 1840 bis Jetzt). L. Koch. With tables and diagrams showing the growth of the railway systems of the iron and steel district of Germany. 4000 w. Glasers Annalen—Dec. 1, 1904. No. 66829 D.

Russia.

The Railways of Eastern Asia and the Russo-Japanese War (Die Eisenbahnen Ostasiens und der Russisch-Japanische Krieg). Dr. Franz Ritter v. Le Monnier. A review of the railway transport facilities of Russia and Japan, and their relation to military movements. Two articles. 7000 w. Zeitschr d Oesterr Ing u Arch Ver—Dec. 29, 1904. No. 66822 each D.

STREET AND ELECTRIC RAILWAYS

Bonding.

The Bonding of the Brooklyn Elevated Railway System. F. H. Parke. Illustrated description of the method of bonding a structure which has been in use some time. 3000 w. St Ry Jour—Dec. 24, 1904. No. 66776 C.

Boston Elevated.

Depreciation on the Boston Elevated Railway. Howard S. Knowlton. Information concerning the conditions on this road, and the work of maintenance as carried out. 1500 w. Elec Rev, N Y—Dec. 3, 1904. No. 66481.

Brakes.

The Efficiency of Power Braking in Street Railway Service, with Tests of Power Consumption of the Air Brake. Edward Taylor. An analysis of the conditions met with in the application of power brakes to electric equipment, with notes and facts in regard to tests made by the writer. 4000 w. St Ry Jour—Dec. 24, 1904. No. 66777 C.

Car House.

The Car House of the Subway Divisic Interborough Rapid Transit Co. Illustrate detailed description of the building at 148th st. and 7th ave., New York. 2000 w. Eng Rec—Dec. 3, 1904. No. 66479.

Chamonix.

The Chamonix Railway (Le Chemin de Fer de Chamonix). F. Loppé. An illustrated description of the electric railway operated by the Paris, Lyons and Mediterranean Company from Fayet to the Swiss frontier. Serial. Part I. 2000 w. Revue Technique—Nov. 10, 1904. No. 66832 D.

Circuit Breakers.

Checking the Adjustment of Car Circuit Breakers. E. C. Parham. Suggests a method whereby the adjustment of a car circuit breaker can be tested in from one to three minutes. 1500 w. St Ry Jour—Dec. 31, 1904. No. 66986 C.

Construction.

Standards of Construction on the Indianapolis Northern Lines of the Indiana Union Traction Company. Illustrates and describes work on the latest lines of the company, which is the second largest interurban system in the United States. 2500 w. St Ry Jour—Dec. 17, 1904. No. 66704 C.

Cost of Power.

Cost of Power in Street Railroad Service. R. C. Carpenter. Gives tabulated results showing the actual performance of street railroad power plants operating under wide ranges of conditions. 1200 w. Sib Jour of Engng—Dec., 1904. No. 66656 C.

Electric Locomotives.

Rapid Transit and the Electric Locomotive. Howard S. Knowlton. Discusses the application of electric locomotives for suburban service, and the future outlook, the advantages and disadvantages, and the effect on the engineers running high-speed trains. 2500 w. Am Elect'n—Dec., 1904. No. 66493.

Electrification.

The Metropolitan Railway. An account of the opening of this newly "electrified" London railway, with illustrated description of the plant. 4000 w. Elect'n, Lond—Dec. 16, 1904. Serial. 1st part. No. 66918 A.

English Tramway.

The Electric Tramways of Preston. Illustrated description of the line, overhead equipment, rolling stock, etc. 2300 w. Tram & Ry Wld—Dec. 8, 1904. No. 66770 B.

Extension.

Paris-Orleans Electric Railway Extension. An illustrated article reviewing the history of electric traction on these lines, and describing recent extension and improvements. 4000 w. Elec Rev, Lond—Dec. 2, 1904. No. 66629 A.

High Speed.

High Speed Electric Railway Work. F.

We supply copies of these articles. See page 876.

W. Carter. Read before the Rugby Engng. Soc. Discusses the conditions of actual service; heavy trains taking power almost continually, train resistance, speed, &c., stating conclusions. 1600 w. Mech Engr—Dec. 24, 1904. No. 67012 A.

Heavy Traction.

Problems of Heavy Electric Traction. O. S. Lyford, Jr., and W. N. Smith. Considers some of the questions brought out in the engineering of the work in progress for the Long Island Railroad Co., describing particularly some of the simple things that were done to facilitate decision regarding motor equipment for cars. 7000 w. Trans Am Inst of Elec Engrs—Nov. 25, 1904. No. 66650 D.

Problems of Heavy Electric Traction. O. S. Lyford, Jr., and W. N. Smith. Abstract of a paper presented at meeting of the Am. Inst. of Elec. Engrs. An illustrated article describing changes to be made in the Long Island Railroad system, the electrification of the suburban service, etc. Also discussion. 7500 w. St Ry Jour—Dec. 3, 1904. No. 66490 C.

High-Speed.

An American High-Speed Electric Railway. A brief, illustrated description of the third-rail system between Aurora, Elgin and Chicago. 800 w. Tram & Ry Wld—Dec. 8, 1904. No. 66769 B.

Some Notes on High-Speed Electric Railway Work. F. W. Carter. Read before the Rugby Engng Soc. Considers in a general way the problem of operating high-speed passenger trains making few stops. 2800 w. Prac Engr—Dec. 16, 1904. No. 66914 A.

Improvements.

Division Terminal Improvements in New Jersey—New Shop Methods. An illustrated article describing new work recently carried out in the mechanical and electrical departments of the Public Service Corporation of New Jersey. 4000 w. St Ry Jour—Dec. 10, 1904. No. 66581 C.

Interurban.

Chicago & Milwaukee Electric Railroad. Illustrates and describes extensions and improvements, the installation of new power house and substation equipments, operating features, etc. 6500 w. St Ry Rev—Dec. 20, 1904. No. 66706 C.

The Joliet, Plainfield & Aurora Railroad. Illustrated description of this recently completed electric interurban line in Illinois. 4000 w. St Ry Jour—Dec. 24, 1904. No. 66775 C.

The Scioto Valley Traction Company. An illustrated description of the only line in Ohio operated by a third rail. 4000 w. St Ry Jour—Dec. 3, 1904. No. 66488 C.

Jungfrau.

The Jungfrau Railway and Tunnels (Die Jungfraubahn und der Bau ihres Tunnels). Paul Möller. With numerous illustrations showing the construction of the railways thus far completed, and the plans for the continuation to the summit. Two articles. 7500 w. Zeitschr d Ver Deutscher Ing—Nov. 12, 26, 1904. No. 66804 each D.

Local Service.

Local Electric Service of the Orleans Railway (Traction Electrique der Trains de Banlieue de la Compagnie d'Orleans). F. Paul-Dubois. A description of the generating station locomotives, rolling stock and operation of the Orleans railway between Paris and Juvisy, a distance of about 12 miles. 5000 w. 4 plates. Rev Gen d Chem de Fer—Dec., 1904. No. 66838 G.

London Station.

The Great London Power Station. Harold J. Shepstone. Brief, illustrated description of the great generating station at Chelsea, London, to furnish the necessary power for working the Metropolitan District and other London railroads. 1500 w. Sci Am—Dec. 17, 1904. No. 66663.

London Underground.

Underground Railways of London. Map and notes from the *Statist*, giving an idea of the extent of the transformation work in progress in changing the lines to electric power. 1700 w. Eng Rec—Dec. 31, 1904. No. 66962.

Mont Blanc.

Electric Railway Up Mont Blanc. Brief description of proposed line, with profile. 800 w. Ry Age—Dec. 30, 1904. No. 66967.

Moving Platforms.

Proposed Moving Platforms Under Thirty-fourth Street, New York. Illustrations showing the location and plans for this proposed subway to be used as a feeder to other lines. 600 w. R R Gaz—Vol. XXXVII, No. 28. No. 66767.

The Moving Platform for Local Passenger Travel. An illustrated description of the modern moving platform and its operation, with especial reference to the proposed construction in a subway of New York City under 34th st., or 35th st. 2300 w. Ry Age—Dec. 23, 1904. No. 66774.

Multiple-Unit.

The Conditions of Electric Traction on Metropolitan Railways (Des Conditions de la Traction Electrique sur les Chemins de Fer Métropolitains). Maurice Soubrier. A discussion of the advantages of the multiple-unit system, with especial reference to the rapidity and acceleration. Serial. Part I. 3000 w. Revue Technique—Nov. 25, 1904. No. 66833 D.

We supply copies of these articles. See page 876.

New Zealand.

The Wellington, N. Z., Tramways. Brief, illustrated description of the construction work. 1200 w. St Ry Jour—Dec. 3, 1904. No. 66489 C.

Operation.

Operating Features of the Seattle Electric Company. Gives details of car operation and the handling of the trainmen. Ills. 5000 w. St Ry Jour—Dec. 17, 1904. No. 66705 C.

Paris.

Underground Electric Railway Work in Paris. Francis Paul. An illustrated detailed description of new construction on the Paris Metropolitan. 2500 w. Am Elect'n—Dec., 1904. No. 66492.

Recent Developments on the Paris-Metropolitan Railway System. An illustrated account of the opening of a new section, and giving information in regard to the entire system. 2000 w. St Ry Jour—Dec. 31, 1904. No. 66985 C.

Portland, Ore.

Notes on the Portland Railway Company's System. A brief illustrated description of the Portland Heights scenic line and its operation. 6000 w. St Ry Jour—Dec. 31, 1904. No. 66984 C.

Power Plant.

Mechanical Features of the Twin City Rapid Transit Company's New Power Plant. Howard S. Knowlton. Illustrated description of the coal bunkers and conveyors, boiler plant, engine room, etc. 2500 w. Eng Rec—Dec. 10, 1904. No. 66615.

The Power Station of the Scioto Valley Traction Company. Illustrated detailed description of the plant at Reeses, Ohio, of a typical high-grade interurban railway. 2000 w. Eng Rec—Dec. 3, 1904. No. 66470.

Rapid Transit.

Rapid Transit Railroad Construction at Battery Park, New York. An illustrated detailed description of the reinforced concrete subway at the lower end of Manhattan. 4000 w. Eng Rec—Dec. 24, 1904. No. 66780.

The Philadelphia Rapid Transit Railway. An illustrated description, with map, of a partly underground and partly elevated structure in progress in this city, which will eventually prove one of the great urban rapid transit railways of the world. 5000 w. Eng News—Dec. 29, 1904. No. 66943.

Speed.

Average Speed and Speed Allowances. A. R. Fearnley. Read before the Assn. of Tram. & Light Ry. Officials at Wakefield. Discusses the speeds allowed on British tramways, suggesting an increase. General discussion. 4300 w. Tram & Ry Wld—Dec. 8, 1904. No. 66772 B.

Subways.

Proposed Passenger Railway Subways for Chicago, Illinois. An illustrated account of proposed subways and estimate of cost. 1800 w. Eng News—Dec. 22, 1904. No. 66765.

Tracks.

Permanent Way for Tramways. Charles T. Taylor. Abstract of a paper read before the Rugby Engng Soc. A discussion of details of track, rail bed or foundation, paving, etc. Ills. 4400 w. Elect'n, Lond—Nov. 18, 1904. No. 66618 A.

Tramways.

Running Powers. Stephen Sellon. Read before the Tram. & Lgt. Rys. Assn. Discusses railway working in England, and the advantages of running through cars without change, with summary of discussion, and letters from numerous tramway engineers and managers. 11000 w. Elec Engr, Lond—Dec. 9, 1904. No. 66725 A.

Vienna.

The Arrangement of the Underground Conductors of the Vienna Electric Tramways (Die Elektrische Einrichtung für die Unterleitung der Wiener Städtischen Strassenbahnen). P. Poschenrieder. With general plan of the system, and sections of the underground conduits showing the arrangement of the conductors. 5000 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 18, 1904. No. 66818 D.

Wheels.

Tramway Car Wheels and Rails. Some Notes on Cost and Maintenance. A. N. Banister. Read before the Assn. of Tram. & Lgt. Ry. Officials at Wakefield. Notes on cost and maintenance, with discussion. Ills. 5000 w. Tram & Ry Wld—Dec. 8, 1904. No. 66773 B.

Wisconsin.

Electric Railways at Green Bay, Wis. Illustrated description of the system of the Green Bay Traction Co., which was formed by the consolidation of several lines. 3000 w. St Ry Jour—Dec. 10, 1904. No. 66580 C.

We supply copies of these articles. See page 876.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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CARD INDEX.—These pages are issued separately from the Magazine, printed on one side of the paper only, and in this form they meet the exact requirements of those who desire to clip the items for card-index purposes. Thus printed they are supplied to regular subscribers of THE ENGINEERING MAGAZINE at 10 cts. per month, or $1.00 a year; to non-subscribers, 25 cts. per month, or $3.00 a year.

THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Review. *m.* Montreal.
Cassier's Magazine. *m.* New York.
Cement. *b.-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.

Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe, U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Científico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Page's Weekly. *w.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Public Works. *m.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.

CURRENT RECORD OF NEW BOOKS

NOTE—Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to THE ENGINEERING MAGAZINE.

Bridges.

Types and Details of Bridge Construction. Part I. Arch Spans. By Frank W. Skinner. Size 9 in. by 6 in.; pp. vii, 294. Price, $3.00. New York: McGraw Publishing Company.

Mr. Skinner has prepared, in convenient book form, a classified record of examples of a number of the most noted arch bridges which have been actually constructed, omitting masonry arches. The collection includes wooden, combination, wrought-iron, and steel arches, for both highway and railroad service, and it is fully illustrated from photographs and from working diagrams, showing details of construction and methods of erection.

Such a record is of undoubted value, even though given, as in this case, with little or no expression of opinion, the engineer being left to form his own deductions from the material exhibited, a method which, while not perhaps well adapted for students, is probably to be preferred for the designing engineer. Most of the designs shown have been described and illustrated in the pages of the engineering journals from time to time, but it is a manifest convenience to have them gathered in book form for reference.

In some instances the methods of computation employed are given, the majority of the bridges are simply described, together with an account, in some of the more important instances, of the methods used in the erection of the spans. The bridges are classified as wood and iron arch spans, spandrel-braced arches, arch trusses, plate-girder arches, and in a few instances cantilever bridges have been included. The list of bridges described is not claimed to be complete, but the designs are very well selected, and the extent to which constructive features are shown renders the whole a typical reference set of the most important structures in various parts of the world. It is to be regretted that in many instances the names of the designers have not been given, as most of the works are of such importance as to make it desirable that the memory of the eminent engineers should be associated with their works, but this is only a slight omission, compared with the information which is furnished.

Electric Transmission.

The Electrical Transmission of Energy. A Manual for the Design of Electrical Circuits. By Arthur Vaughan Abbott, C. E. Size, 9 in. by 6 in.; pp. xxx, 675. Price, $5.00. New York: D. Van Nostrand Co. London: Crosby Lockwood and Son.

It is an excellent commentary on the development of the practical applied science of electricity that a treatise on electrical transmission which was originally written as recently as 1894 should have passed to its fourth edition, and especially that this fourth edition should be announced as having been entirely rewritten as well as enlarged. As the author himself says in his introduction to the new edition, since the appearance of the second edition in 1898, the practice of transmitting energy by means of electricity has extended by leaps and bounds until to-day one can hardly gaze from the window of a railway train without encountering the pyramidal cross arms of a transmission circuit.

Mr. Abbott has limited himself wholly to the subject of transmission, in which, however, he includes the mechanism of converters and transformers, but omits consideration of general power house machinery, as fully discussed elsewhere. The scope of the work is well indicated by a summary of the contents, which include a discussion of the properties of wire, an exhaustive treatment of aerial circuit construction, of underground circuits, and of special railway circuits. Methods of electrical measurement are treated, both from the standpoint of the physical laboratory and of the outdoor operator, while methods of distribution both by series and in parallel, are given extensive discussion. A chapter is devoted to polyphase distribution, and the work closes with a chapter on the cost of production and distribution.

A special feature of the work is the printing of the important tables and diagrams on separate sheets, folded into a portfolio in the back cover, from which they can be taken as loose leaves. This will doubtless facilitate their use, but may also permit them to get into the hopeless category of "lost, strayed, or stolen."

Foundations.

Ordinary Foundations, including the Coffer-Dam Process for Piers. By Charles Evan Fowler, C. E. Size, 9 in. by 6 in.; pp. xxvi, 314. Price, $3.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

The object of this work is clearly stated by the author to be the provision of practical information concerning a department of work which has been largely left untreated because of the importance of discussing the construction of difficult foundations. A great and troublesome piece of foundation work naturally receives publicity in proportion to its magnitude, while the general engineer and constructor finds that by far the larger portion of his work is of an ordinary character, and requires simply a good acquaintance with what has been done by others under similar conditions. It is this knowledge of the practical working methods involved in ordinary foundation construction, with especial reference to the use of the coffer-dam methods of building bridge piers, which Mr. Fowler aims to supply, and his work will doubtless find welcome acceptance by many. A brief historical chapter is followed by an account of coffer-dam construction, illustrated by examples taken from current practice. Methods of crib construction are illustrated, with timber and sheet metal piling, together with a discussion of methods of stopping leaks, and driving piles. The practical methods of pumping a dredging are also treated, as well as the sinking of cylinders and caissons.

Having thus shown the practical working methods of reaching the basis upon which the foundation is to be erected, the remainder of the book is devoted to the actual construction of the foundation, including the location of piers, the use of various kinds of stone, data concerning cement and concrete, and timber piers and timber preservation. The appendix includes specifications for well-known dams, bridges, piers and coffer dams, and the work contains a number of useful tables of the properties of the materials required for foundation work.

Mechanical Movements.

Mechanical Appliances, Mechanical Movements, and Novelties of Construction. By Gardner D. Hiscox. Size, 9 in. by 6 in.; pp. 396. Price, $3.00. New York: The Norman W. Henley Publishing Co.

This work forms practically a supplement to the book of mechanical movements by the same author, and contains a number of interesting groups of movements not included in the former work. The various groups include lever combinations, power transmission, power measurement, various methods of power generation, transportation by railway, road, and water, gearing, horology, and a number of machine and factory appliances. An interesting portion of the book is that giving brief descriptions of a number of the devices which have been proposed in connection with the effort to produce a perpetual motion machine, these, it may be, serving to show to those who may yet be working upon that fallacy, that their ideas have been anticipated and that failure must surely follow.

Works of this sort bear the same relation to invention and machine design that the dictionary and the encyclopædia do to the literary worker. By having at hand a convenient reference giving the methods which have been adopted by others for the attainment of given results much time is saved, and in many instances some simple device is found to perform what a much more complicated apparatus might otherwise have been made.

In the modern drawing room the provision of a moderate library of well selected reference books is found to prove a marked economy, and among such works the best collections of mechanical movements will be found of great use, not only during the preparation of a design, but frequently in the decision as to the whole plan to be adopted before the details are worked out. Such works as these are also of much service to patent attorneys in conducting searches as to the novelty of devices under consideration, or proving the anticipation of claims under contest, and they belong to the reference shelf of every well selected engineering library.

Mechanism.

Elements of Mechanism. By Peter Schwamb, S. B., and Allyne L. Merrill, S. B. Size, 9 in. by 6 in. Price, $3.00; pp. vi, 264. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

Primarily compiled in the form of notes for the use of students at the Massachusetts Institute of Technology, this work is now issued in book form as a text book, and as such it forms an acceptable epitome of such well-known treatises as Reuleaux's "Kinematics of Machinery," Reuleaux's "Constructor," Robinson's "Principles of Mechanism," MacCord's "Kinematics," Rankine's "Millwork and Machinery," Goodeve's "Elements of Mechanism," and Unwin's "Machine Design."

To have boiled down all that was in these important works was found impossible either in a student course or in a set of lecture notes, but the present work does give a condensed course which will enable the student, whether in a technical school or in private study, to obtain a general grounding upon which he can de-

velop his work according to the demands of his future practice.

It might be suggested that in such a work the academic methods of developing the curves for gear teeth should be supplemented with some brief account of the methods now employed in the best shops for generating the true curves directly in the gear cutting machine, since some of these machines offer the most instructive examples of the manner in which the geometrical operations of laying out gear teeth have been rendered obsolete in the drawing room by their transference to the machine itself.

The book will doubtless find useful application as a condensed treatise on the subject, apart from its use as a text book in the institution for which it was designed.

Tanks.

Towers and Tanks for Waterworks. The Theory and Practice of Their Construction. By J. N. Hazlehurst. Second Edition, Revised and Enlarged. Size, 9 in by 6 in.; pp. x, 325. Price, $2.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

The general importance of the subject of water towers and tanks and the propriety of a special treatise upon their construction is shown by the fact that a special book on the subject has reached a second edition within a short time. As the author says, it has been the custom to buy a stand-pipe in much the same manner as a barrel of flour, or any other staple article, the stipulations being only for size or capacity, with some statement as to the character of the workmanship. The natural result of such a method has been a disastrous record of stand-pipe failures, so that the previous book upon the subject, by Prof. Pence, was devoted entirely to the subject of failures and breakdowns. This portion of the work has been continued by Mr. Hazlehurst, although his book is primarily one dealing with the correct principles of design and methods of construction.

After chapters dealing with the strength of the materials employed, and the nature of the stresses to be resisted, Mr. Hazlehurst proceeds to consider the principles of design and the details of tank construction. With these are included discussions of the construction of foundations, erection, painting, and ornamentation.

The list of failures, including the work of Prof. Pence and the author, is sufficient evidence of the necessity for the employment of competent engineering advice in the design of such important structures as water towers, and in this book the principles are given with sufficient fulness to enable the waterworks constructor to make plans which should be satisfactory. It is to be regretted that the method of Professor Intze is not included in the discussion of the design of the bottoms of metal tanks, since this plan enables the form to be so proportioned that the horizontal stresses will exactly neutralize each other. The Intze form of tank bottom is now extensively used in Germany, and it is undoubtedly superior to the hemispherical form advocated by Mr. Hazlehurst.

The book is an excellent one of its kind, and a valuable addition to the list of treatise upon special structural subjects now becoming general.

Tools.

American Tool Making and Interchangeable Manufacturing. By Joseph V. Woodworth. Size, 9 in. by 6 in.; pp. 560. Price $4.00. New York: The Norman W. Henley Publishing Co.

Ever since the time of Eli Whitney, who at the close of the 18th century originated the art of interchangeable manufacturing as applied to firearms, the use of jigs and special fixtures has been in constant and increasing use in American workshops. The development of the art in the United States has been such that at the present time it well merits a special treatise, and this want has been supplied in the book which Mr. Woodworth has prepared. This is rather a descriptive than an analytical work, and in it are described and illustrated all the different types and classes of small tools, fixtures, devices and special appliances available for use in machine manufacturing and metal-working establishments. The appliances described in the book are taken from examples in actual and practical service in many shops throughout the United States, and it is by the employment of just such methods that the modern shop has succeeded in increasing outputs and thus reducing the proportion of general expense to the increase of income.

Formerly the methods and appliances which are described in such a book as Mr. Woodworth has made were kept closely guarded in the secret recesses of a special tool room and experimental department, but it is now recognized that the benefit gained by publicity and interchange of methods and information far exceeds that which can be secured by the old-time secretiveness, and the result appears in the fulness with which the author has been enabled to give the shop processes, tools, and methods of the leading manufacturing establishments of America.